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SHAPING A PEDAGOGICAL DESIGN FOR USE IN THE CLASSROOM IN A DEPRIVED AREA

SINGLE-CASE STUDY: A HONDURAN PRIMARY SCHOOL

BY
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AALBORG UNIVERSITY
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CV

Mirna Rivera holds master's degrees in communication for development from Malmö University, Sweden, and business administration from Universidad Tecnológica Centroamericana (UNITEC), Honduras, she holds bachelor`s degrees in journalism from Universidad Nacional Autónoma de Honduras and communication and information from California State University, Chico, USA (Fulbright Program). She has worked as lecturer and dean of the School of Business Administration and Social Sciences in higher education at UNITEC. She has more than ten years' experience working as a specialist in corporate social responsibility. In 2014, she entered the doctoral program in human-centered communication and informatics in the e-Learning Lab—Center for User Driven Innovation, Learning, and Design, Department of Communication and Psychology, Aalborg University.

In her thesis, she studied the constraints and contradictions to introduce problem/project-based learning in a Honduran public elementary school in a deprived urban area and she proposed a pedagogical design, resulted of the empirical testing in the classroom and shaped by the students, teachers, and researcher, integrating PBL, XO computers, and 21st-century skills to strengthen the microsystem that she call Inside-Outside to support student-center education in impoverished areas.

ENGLISH SUMMARY

This research provides a theoretical and practical understanding of the use of information and communication technology (ICT) and pedagogical practices in a classroom in a public school in an underprivileged context. This study examines the contradictions and constraints of the current teacher–student interactions and proposes a different way to engage children as the center of the learning process by introducing problem/project-based learning (PBL) principles into lesson design (de Graaff & Kolmos, 2007; Dewey, 1916; Larmer, Mergendoller, & Boss, 2015).

Educational design research (McKenney & Reeves, 2012) was the methodology used to conduct this study, which consisted of three main phases: analysis and exploration; design and construction; evaluation and reflection. In each phase, different theories were used to analyze the data. The theory of constraints (Goldratt, 1990) was applied to identify potential solutions to overcome the main limitations to integrating active learning, specifically problem/project-based learning (PBL) and ICT. The pedagogy of the oppressed (Freire, 1970) was adopted as an educational theory to understand the effects of traditional ways of teaching and the use of XO computers in the classroom. I used activity theory (Engeström, 1987) to analyze the contradictions during the implementation of the lesson design prototype integrating ICT and PBL into the classroom.

This study followed a participatory approach in which practitioners played an important role, and teachers' and students inputs' were considered to be relevant to identifying the constraints and seeking solutions for their challenges during the fieldwork. One of the main data collection methods was a future workshop, a participatory technique to understand the research context, promote critical thinking and teamwork, and empower the participants to develop solutions (Jungk & Müllert, 1987). I also adopted visual anthropology as a visual method to describe the internal and external limitations in which the school operated (Collier & Collier, 1986).

In my triple roles as a researcher, facilitator, and designer, I sought to study the current teaching practices in the classroom and propose a design to shift from a teacher-oriented to a student-centered approach integrating ICT through an active learning model (McKenney & Brand-Gruwell, 2015). Along with the teacher, I proposed two prototype designs: a workshop design to train teachers in PBL principles and a lesson design to integrate PBL and XO computers into the classroom. Both used common PBL learning principles based on collaborative learning, cognitive learning, and contents (De Graff & Kolmos, 2003; 2007; Du et al., 2009).

This research partly fills the literature gap on low-income public schools in impoverished areas regarding the proper use of ICT and pedagogical skills to engage teachers and students in an active learning process that allows them to develop 21st-century skills for critical thinking, problem solving, and communication (Scott, 2015).

I propose a pedagogical design integrating PBL, XO computers, and 21st-century skills for use in the classroom with children attending schools in deprived areas. In addition, I propose the development of what I call the inside-outside microsystem with the aim to boost students' academic potential in order to equip them to transform themselves and make positive impacts on the external world in which they navigate the threats of high crime rates, gangs, extreme poverty, and overcrowding every day. Despite such circumstances, school can positively influence children, helping them develop a "learning to learn" mindset in the classroom and providing them with opportunities to use their knowledge to transform their own reality.

DANSK RESUME

Afhandlingen giver en teoretisk og praktisk forståelse af brugen af informations- og kommunikationsteknologi (IKT) og pædagogisk praksis i et klasseværelse i en offentlig skole i en underprivilegeret kontekst. Forskningsprojektet undersøger modsigelser og begrænsninger i de nuværende interaktioner mellem lærer og studerende og foreslår en anden måde at engagere børn som centrum i læringsprocessen ved at introducere problem- og projektbaseret læring (PBL) - principper i læringsdesign (de Graaff & Kolmos, 2007; Dewey, 1916; Larmer, Mergendoller, & Boss, 2015).

Metoden Design-Based Research (McKenney & Reeves, 2012) blev anvendt til at gennemføre denne undersøgelse, som bestod af tre hovedfaser: analyse og udforskning, design og konstruktion, og evaluering og refleksion I hver fase blev forskellige teorier brugt til at analysere de indsamlede data. Teorien om Constraints (Goldratt, 1990) blev anvendt til at identificere potentielle løsninger til at overvinde de vigtigste begrænsninger for at integrere aktiv læring, specifikt problem- og projektbaseret læring (PBL) og IKT. The pedagogy of the oppressed (Freire, 1970) blev anvendt som en pædagogisk teori for at forstå virkningen af traditionelle måder at undervise og anvende XO-computere i klasseværelset. Activity theory (Engeström, 1987) blev anvendt til at analysere modsætningerne under implementeringen af en første version af læringsdesignet, der integrerede IKT og PBL i klasseværelset.

Denne undersøgelse fulgte en deltagende tilgang, hvor praktikere spillede en vigtig rolle, og lærernes og studerendes input blev betragtet som relevante for at identificere begrænsningerne og finde løsninger på deres udfordringer i feltarbejdet. En af de vigtigste dataindsamlingsmetoder var en Future Workshop, en deltagende metode til at forstå konteksten, fremme kritisk tænkning og teamwork og give deltagerne mulighed for at udvikle løsninger (Jungk & Müllert, 1987). Visuel antropologi blev anvendt som en visuel metode til at beskrive de interne og eksterne begrænsninger, som skolen opererede i (Collier & Collier, 1986).

Forskeren havde en tredobbelt rolle som forsker, facilitator og designer og studerende gennem disse roller den aktuelle undervisningspraksis i klasseværelset og foreslog på denne baggrund et design til at skifte fra en lærerorienteret til en studentercentreret tilgang, der integrerer IKT gennem en aktiv læringsmodel (McKenney & Brand-Gruwell, 2015). Sammen med læreren udvikledes to prototype-designs: et workshop-design til at uddanne lærere i PBL-principper og et læringsdesign til at integrere PBL- og XO-computere i klasseværelset. Begge anvendte almindelige PBL-indlæringsprincipper baseret på samarbejdsindlæring, kognitiv læring og indhold (De Graff & Kolmos, 2003; 2007; Du et al., 2009).

Denne undersøgelse udfylder delvist den begrænsede forskning vedr. offentlige skoler med lav indkomst i fattige områder med hensyn til relevant brug af IKT og

pædagogiske færdigheder til at engagere lærere og studerende i en aktiv læringsproces, der giver dem mulighed for at udvikle færdigheder i det 21. århundrede til kritisk tænkning, problemløsning og kommunikation (Scott, 2015). Projektets slutprodukt var et pædagogisk design, der integrerer PBL-, XO-computere og det 21. århundredes færdigheder til brug i klasseværelset med børn, der går på skoler i dårligt stillede områder.

Derudover blev der udviklet et koncept kaldet 'inside-outside' mikrosystem med det formål at øge elevernes akademiske potentiale med henblik på at give dem kompetencer til at transformere sig selv og gøre positive effekter på den eksterne verden, hvor de navigerer mellem truslerne om høj kriminalitet, bander, ekstrem fattigdom og overfyldning hver dag. På trods af sådanne omstændigheder kan skolen have en positiv indflydelse på børn, hjælpe dem med at udvikle en "læring til at lære" tankegang i klasseværelset og give dem muligheder for at bruge deres viden til at transformere deres egen virkelighed.

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My dear Lord, thank you for giving me the strength and wisdom to complete this dissertation. This time in my life has allowed me to grow academically, professionally, and spiritually.

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DEDICATION

I dedicate this study to all the children living in deprived areas and attending underprivileged schools, especially the children of my country. They deserve a better present to have a great future.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1. INTRODUCTION TO THE STUDY

This introductory chapter presents an overview of the main aspects studied in this research. I describe the potential of information and communication technology (ICT) and the adoption of student-centered pedagogy to bridge the digital gap. In addition, I give an overview of the main limitations to filling the educational and technological gap and formulate the problem and the research questions taking into consideration the national and local context of the intervention. Finally, I explain how the thesis is structured.

1.1 RESEARCH BACKGROUND

The incorporation of ICT into education presents an opportunity to accelerate the digital inclusion of disadvantaged people living in marginalized areas. ICT use in the classroom calls for implementing a pedagogical approach that allows students to transform their reality by using computers to re-create their world so that they become the center of the learning process.

Practicing pedagogy in the 21st century demands critical thinking, problem-solving, and communication skills to express oneself in different ways. Consequently, knowledge and collaboration are the main elements in learning to learn, to do, to live together, and to contextualize being (Scott, 2015). The pedagogy of the question should be used rather than the pedagogy of the response, which Freire (1970, p.58) named "the banking" approach in education, which jeopardizes opportunities for people liberate themselves from the oppression of the dominant system.

Use of technology in the classroom, though, is not new. In the past century, television and radio were introduced, along with the blackboard and chalk, in some cases with the intent to replace teachers (Cuban, 1986). ICT by itself will not build a bridge between the haves and have-nots; instead, it requires a strategic effort to lead the education system into a more inclusive model to promote the social mobility. This research has a theoretical and practical scope and is intended to identify the main constraints and contradictions to integrating ICT use by focusing on human–computer interactions and the introduction of problem/project-based learning (PBL) as a pedagogical philosophy in public schools in an underprivileged area of Honduras.

1.2 INFORMATION AND COMMUNICATION TECHNOLOGY AND PEDAGOGY

Today, the information revolution allows more individuals to access educational resources and discover knowledge for themselves. Flecha (1999, p. 66) pointed out that "mental capacities are much decisive than they were in the industrial society.

Increasingly, success is different areas of social life depends on culture we carry with us, the knowledge and skills we possess. This has led some to claim that the information society is more democratic and egalitarian than its predecessors because material resources, which predominate in industrial society, are extremely unequally distributed, while mental factors, which now predominate, are given to all."

In the 21st century, the use of technology is essential to develop those mental capacities. As Papert (1982, p. 60) claimed, that computer are tools that help students to achieve by themselves "powerful intellectual skills" during the process because children can put logic into practice and create their own prototypes. However, there is a digital and educational gap between developed and developing countries, with most schools in high-income countries connected to the Internet, while schools in low-income countries lack connectivity (International Telecommunication Union, 2014).

Technology can be a means to create new things and a helpful aid to motivate students to learn, taking into consideration individual's needs to build up knowledge. ICT "is certainly not a panacea for education, but it is a powerful tool that when implemented appropriately can catalyze and accelerate education reform and development" (Unwin, 2014, p. 207). Investing in technology in the classroom and training teachers to shift from traditional pedagogical models to new, more collaborative approaches, focused on student-centered learning such as PBL, can contribute to the practice of constructionist education methods for the digital era (Ryberg, 2013).

According to Savin-Baden and Howell Major (2004, pp. 11), "problem-based learning in which it is acknowledged that learners should develop metacognitive skills and thus it is expected that students use reasoning abilities to manage or solve complex problems." Most research on PBL has been conducted at universities, and Aalborg University has been a pioneer, applying this methodology since 1970. However, PBL remains relatively new on the primary and secondary school levels. Some critics have attributed this to the greater guidance required for PBL at this level because the population lacks sufficient prior knowledge to solve problems, in contrast to other scholars who have claimed that prior knowledge is compatible with human cognitive architecture (Wirkala & Kuhn, 2011). Although PBL is becoming more well known in primary and secondary education in some developed countries such as the United Kingdom, little research has been done in this field (Larmer et al., 2015; Savin-Baden & Howell Major, 2004).

Drawing on Jones, Rasmussen, and Moffitt (1997) and Thomas, Mergendoller, and Michaelson (1999), Thomas (2000, p. 1) defined Project-based learning as "a model that organizes learning around projects. According to the definitions found in PBL handbooks for teachers, projects are complex tasks, based on challenging questions or problems, that involve students in design, problem-solving, decision making, or investigative activities; give students the opportunity to work relatively autonomously over extended periods of time; and culminate in realistic products or presentations."

The principle of PBL is to learn by doing and to boost the creativity and self-expression of learners, so teachers as seen as midwives, while students are the center of the learning process (Dewey, 1963). These concepts are the opposite of teacher-centered approaches based on the principle that human beings are tabula rasa, empty boxes without enough experience to construct knowledge by themselves (Locke, 1689/2009). The PBL educational approach challenges students to learn how to learn and could be a framework to understand how to employ technology for learning and teaching in a pedagogically sound way.

1.3 NARROWING THE EDUCATIONAL AND TECHNOLOGY GAP

The educational and technological situation in developing countries, such as Honduras, which has a population of 9,012,929, features a significant inequality gap between the haves and the have-nots. Higher-income Hondurans attend school for an average of 11.1 years, compared to 5.7 years by lower-income Hondurans; 49.5% complete primary school, 22.9% secondary school, and only 6% higher education. (Instituto Nacional de Estadìsticas, INE, 2018), While 21.5% of the Honduran population has Internet access, there is a technological backwardness: only 9,171 of 25,784 public schools in urban and rural areas have Internet access, and 60.1% of Internet connectivity in schools is reserved for administrative use, with only 39.9% dedicated educational purposes (Informe de Progreso Educativo Honduras, IPEH, 2017; Secretarìa de Educacion de Honduras (SEH), 2017). Moreover, Honduras education is of low quality, most schools use traditional, teacher-centered pedagogical methods, and the infrastructure is poor (Murphy-Graham, 2012).

Bridging the digital and educational gap is the government's responsibility under the Honduran Law of Education (La Gaceta, 2012). The use of technology and the development of digital skills, though, require training to empower teachers and students. Children living in poor conditions have more disadvantages and less academic support from their families than children in the middle and upper classes, who also receive support from the learning culture in their environment (Organization for Economic Cooperation and Development, OECD, 2017). Children living in poverty also have limited access to Internet and computers in public schools.

In view of this situation, the nonprofit Zamora Terán Foundation (ZTF), sponsored by Lafise Group and other private enterprises, is providing Internet and computers to underprivileged schools as part its corporate social responsibility (CSR) programs. ZTF acts as the Honduran partner with the international One Computer Per Child program launched by the Massachusetts Institute of Technology in 2005. Such programs are helping fill the technological gap. However, schools operating in impoverished areas still face other issues I intend to explore and analyze in this research because, as I have argued, technology itself cannot ensure high-quality education, and 64.3% of Honduras's population lives in poverty (INE, 2017). The educational and technological gap arises from an unequal system that encourages

backwardness and a lack of opportunities for social mobility. The role of schools in high-poverty areas must go beyond the transfer of knowledge and Internet access. Schools should serve as centers enabling the psychological and social development of the individuals attending them.

1.4 PROBLEM FORMULATION: DEVELOPING A PROBLEM/PROJECT-BASED LEARNING APPROACH BY USING INFORMATION AND COMMUNICATION TECHNOLOGY

The challenge of using technology and appropriate pedagogies to improve education in public primary schools in areas with low economic resources in developing countries, such as Honduras, points to a need to examine the teaching models and tools used. This research examines the opportunities and challenges of developing a pedagogical model that uses ICT, is based on PBL, and considers the socio-economic context in which these schools operate. PBL principles rely on creating an appropriate classroom environment for students to develop soft and hard skills by working with real-world problems regardless of their economic situation.

Children living in marginalized urban areas face different challenges than children from middle and upper classes. This research focuses on schools in urban poor areas with more than 50,000 inhabitants, where children live in chronic socioeconomic deprivation (Jensen, 2009). ICT can be used to bring more opportunities to the have-nots, but other aspects must also be considered. ICT will not change education or reduce poverty by itself; its results depend on how it is applied in local and international contexts (Roy, 2005). It is naïve to believe that inequality will end simply by distributing more computers. Technology magnifies human intent and capacity but can never improve an underperforming system alone (Toyama, 2015). As Freire (1970) argued, banking education does not give people living in poverty opportunities to understand what is happening around them or empower them to liberate themselves from oppression. Humans need to learn to think of how to construct and reconstruct their circumstances that keep them down and how they can overcome this cycle of inequity.

1.5 RESEARCH AIMS

This research has dual goals: one, to provide to researchers with a theoretical understanding of the currents situation and proposed solutions; and two, to provide practical contributions to the pedagogical field with the aim of enhancing students 21st-century skills , in collaboration with teachers and non-profit organizations providing ICT to public schools operating in impoverished settings and to study the main barriers to overcome to implement a pedagogical model based on PBL principles and use of computers for public primary schools in urban low-income areas (Figure 1).

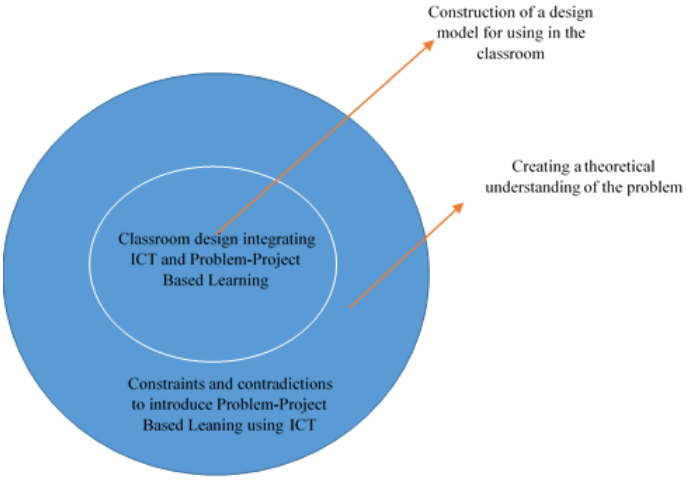

Figure 1. Aims of this research: Theoretical and practical contributions

This research is intended to answer the following questions:

1) What are the main constraints to overcome in order to introduce PBL using ICT in public schools operating in impoverished areas?

2) What kind of design can contribute to implementing PBL using ICT to enhance 21st-century skills?

3) What are the main contradictions inherent in shifting from a traditional (teacher-oriented) pedagogy to active (student-oriented) learning using a model constructed in a participatory manner with the practitioners?

4) How can a new model design in the classroom contribute to enhancing the 21st-century skills of children attending schools operating in impoverished settings?

1.6 SIGNIFICANCE OF THE RESEARCH

This research is intended to strength the Honduran educational model by developing a pedagogical approach based on PBL principles for primary schools, using computers as a main pedagogical tool and involving teachers, students, and foundations in the design of this model (Cuban, 1986; Dewey, 1963; Selwyn, 2011). In addition, this research makes a theoretical contribution to the educational field by introducing this model in urban marginalized areas in developing and developed countries that struggle with similar socio-economic problems, such as high rates of violence, unemployment, family breakdown, and poverty.

1.7 RESEARCH CONTEXT

1.7.1 CITY'S SOCIO-ECONOMIC CONTEXT AND THE EFFECT ON EDUCATION

The research context is a public school in an urban marginalized area in San Pedro Sula, Cortes Department, Honduras' second largest city after the capital, Tegucigalpa. The city's population increased from 600 inhabitants in 1850 to 7,182 in 1900. That year, the acting mayor was José Máximo Rivera Fajardo, my great-grandfather, who was originally from the town of Trinidad in the Santa Barbara department, founded by the descendants of Sephardic Jews (Amaya, 2000; Euraque, 1996; Ventura-Lara, 2008). Today, the population is around 739,038 (INE, 2017).

Economic growth came with the establishment of banana plantations producing exports to the United States, along with the mining industry and construction of the interoceanic railroad. San Pedro Sula is considered to be the country's industrial capital, generating more than 50% of the gross domestic product and 60% of the exports (World Bank Group, WBG, 2018). With an area of 856.25 km, San Pedro Sula ranks as the second most violent place in the world, with 112.09 murders per 100,000 people per year (*Business Insider*, 2017 and 2018).

According to the statistics of the World Bank (2019) in Honduras the urban population living in slums is 27.5% until year 2014. Living in slum household means that people lack of access to water, sanitation, adequate housing and extreme poverty. In San Pedro Sula, around 9% of the population lives in extreme poverty in urban slums known as *bordos* along 16 riverbanks in high-risk areas, where crime provides one source of income, and the bicycle is the most common mode of transportation. Every year, the population of these areas increases by 35%, and the residents suffer from insecurity, overcrowding, low self-esteem, conformism and discrimination due to their social status (Diario *La Prensa*, 2017). Most children living in low-income areas attend public schools, and there are 2,028,304 students enrolled in the system. However, the drop-out rated has increased, from 2.7% in 2015 to 2.9% in 2016. According to official data, the main causes are migration, child labor, poverty, and violence related to organized crime (*El Heraldo*, 2018; SE, 2017).

1.7.2 PUBLIC EDUCATION CONTEXT

Based on the Republic of Honduras Constitution (La Gaceta, 1982), the new Honduran Education Law (La Gaceta, 2012) replaced the previous law passed in 1966. Article 57-73 states that the Honduran educational model should be student oriented, open, and flexible and promote community participation. This article requires the engagement of teachers, who must have college degrees in education by 2018 to work in the education system. This model uses ICT, is inclusive and results oriented, and promotes a participatory structure. Article 74-79 calls for parents, tutors,

and community members to become involved, including in hiring decision for new teachers to make the process more transparent.

Article 13 states that education is free and mandatory through twelfth grade. High-quality, secular education should promote democracy, citizen participation, transparency, accountability, environmental responsibility, interculturality, multiculturality, and education for life and for work. A minimum of 200 days of classes are required to complete a school year, which, in the public education system, begins in February and ends in November.

Unfortunately, enforcement of this law is weak and challenging for the national government, which lacks the necessary economic, human, and technological resources. The education system has around 2.2 million students and 60,000 teachers, while 30% of the population is illiterate, according to government data. (SES,2017) Although education is free, teachers do not always receive their salaries on time, and schools lack teaching materials. The government has recognized that it has insufficient infrastructure to provide pre-basic education to children 4–6 years old.

Another aspect undermining educational progress is the lack of transparency and accountability (El Heraldo, 2018; SE, 2017). Honduras is ranked among the most corrupt countries in the world, 135 of 175 countries (Transparency International, 2017). “Corruption Rank in Honduras averaged 115.05 from 1998 until 2017, reaching an all-time high of 140 in 2013 and a record low of 71 in 2001” (Trading Economics, 2018). The situation negatively affects education, and the educational system has suffered in recent years due to the lack of transparency. The media has reported on many problems related to absenteeism, such as “ghost teachers” who do not exist but receive a salary, teachers who are paid but do not perform their functions, and leakage in textbook distribution and cash transfers (Asociaciòn para una sociedad màs justa, ASJ, 2015).

1.7.3 PUBLIC–PRIVATE PARTNERSHIP FOR DEVELOPMENT TO ENHANCE EDUCATION

To meet the education law, some public schools have started to collaborate with private organizations to integrate ICT into public schools. Businesses do so as part of their CSR efforts in developing countries, such as Honduras, where the governments have not fulfilled their duties, leaving an active role for industry. According to International Organization for Standardization(ISO) 26000: 2010; Instituto de Normas Técnicas de Costa Rica-ISO 26000:2010, social responsibility is “the responsibility of an organization for the impact of its decisions and activities on society and the environment, through transparent and ethical behavior that: is consistent with sustainable development and the welfare of society; takes into account the expectations of stakeholders; is in compliance with applicable law and consistent

with international norms and behavior; and is integrated throughout the organization and practice in its relationships."

Public–private partnerships offer an innovative social model to provide ICT access to disadvantaged people living across the digital divide. Governments' and international organizations' failure to accelerate incorporation of technology into classrooms leaves an empty space that must be filled by another stakeholder: the private sector. This study was carried out in partnership with ZTF (2016), the main ICT provider to the school studied which operates the One Laptop Per Child educational program in 4 of 18 departments in Honduras (Figure 2).

Figure 2. Territorial division and four departments in Honduras where the Zamora Terán Foundation (Fundación Zamora Terán, 2016) runs the One Laptop per Child program

1.7.4 STRUCTURE OF THE THESIS

This thesis is organized into eight chapters.

Chapter 1 gives an overview of this investigation and describes the main points examined in this dissertation, particularly the incorporation of ICT into the classroom and PBL as an alternative to narrow the educational and technology gap. I formulate the problem and the research questions addressed in this dissertation, taking into consideration the research context and the role of the private sector in enhancing the quality of education in schools operating in impoverished contexts.

Chapter 2 explains the origins of problem-based learning (problem-BL) and its adoption in higher education and the reasons why project-based learning (project-BL)

is more well known in primary school settings. I present the learning theories behind this pedagogical model and discuss the main challenges to teaching and using ICT in impoverished contexts.

Chapter 3 presents educational design research (EDR) as the main methodology used to conduct the study and gives an overview of the process throughout the research design. I explain the paradigm, methods, theories, and theoretical framework underpinning the investigation.

Chapter 4 presents an analysis and exploration of the research context. I describe the external and internal situations and identify the main constraints to implementing PBL using computers in marginalized areas with high crime and poverty rates. In this section, I describe using the following methods: visual anthropology (Collier & Collier, 1986), interviews, observations, and future workshops (Jungk & Mullert,1987).

Chapter 5 analyzes the data collected in chapter 4 and merges two theories to understand the core problem: the theory of constraints (TOC; Goldratt, 1990) and the pedagogy of the oppressed (Freire, 1970). This combination of theories allows responding to the following questions: What to change? What are the core problems? To what to change to? How to cause the change?

Chapter 6 describes the steps to build a pedagogical design integrating ICT and PBL. I present a reflection based on Pablo Freire's and John Dewey's discussion of freedom and democracy in education and describe the empirical work with practitioners. I unfold a worst case so that whatever makes improvement here is likely to work everywhere with similar characteristics: low-income families, criminality, and impoverished schools.

Chapter 7 unfold the third phase of the research: evaluation and reflection. I present the prototypes designed during the intervention and reflect on the empirical and theoretical understanding gained. During this phase, I analyze the implementation process using activity theory (AT) to identify the main contradictions and tensions that occurred during the intervention in two sessions at primary schools.

Chapter 8 presents the conclusions and reflections of the research findings. I achieve the two goals of this research: to explore the constraints and contradictions to introducing a student-centered approach in the classroom by using technology; and to design a pedagogical model to integrate the use of computers in classroom lessons. I discuss the limitations of developing a pedagogical model based on PBL principles, along with the study contributions, and give recommendations for further research.

CHAPTER 2. REVIEW OF LITERATURE ON PROBLEM/PROJECT-BASED LEARNING IN PRIMARY SCHOOL SETTINGS

This chapter was previously published as part of a conference paper (Rivera. M. 2018, pp. 4320-4329).

It presents a review of the literature aimed at shedding light on two research topics: (1) What are the main constraints to applying PBL principles in primary education? (2) What type of model can be used to integrate both types of PBL and the use of within an impoverished context? Answering these two questions lead to address one central research question related to identify the main constraints to overcome in order to introduce PBL using ICT in public schools operating in impoverished areas.

This literature review is intended to aid understanding of problem-BL and Project-BL, the philosophical foundations underpinning these models, and the main authors who have contributed to constructing them. The first part of this chapter explains the origins of problem-BL in higher education and its growing recognition and adoption in various combinations (e.g., with project-BL) in primary education. The second part of this chapter explains the learning theories behind this model, while the third part of this chapter reviews the main challenges of teaching in an impoverished context while attempting to introduce both a new model and a new technology. This literature review also provides an overview of ICT in education and describes the challenges of teaching in poverty.

According to Du et al. (2009, p. 9), "PBL is an abbreviation for both problem-BL and Project-based learning, and it has proven to be successful educational strategy in higher education." Problem- and project-based learning have the same abbreviation (*PBL*), so I chose to use *problem-BL* and *project-BL* to distinguish them one another and to increase the clarity for the readers. In some cases, I use the abbreviation *PBL* to refer to both problem-BL and project-BL.

2.1 LITERATURE REVIEW METHODOLOGY

A literature review involves "the selection of available documents (both published and unpublished) on this topic, which contain information, ideas, data and evidence written from a particular standpoint to fulfil certain aims or express certain views of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed" (Hart, 2018 pp. 13). Two major branches of traditional literature reviews are the most common in scholarly

publications, such as journals and books: narrative and systematic literature reviews (Cronin & Ryan, 2008). There are four common types of narrative literature reviews: general, theoretical, methodological, and historical. I chose to conduct a general literature review because this approach "provides a review of the most important and critical aspects of the current knowledge of the topic" (Onwuegbuzie & Frels, 2016 p. 24).

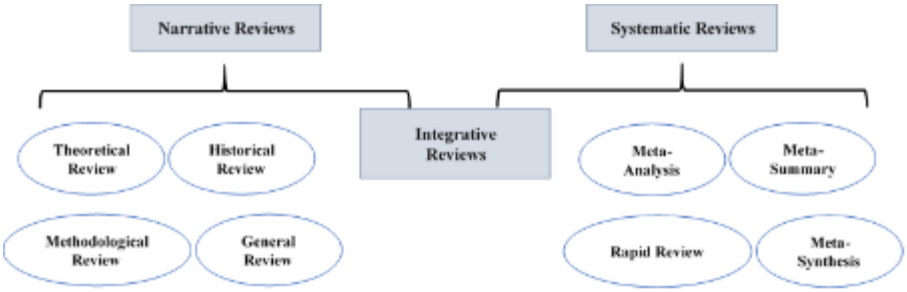

Figure 3. Branches of literature reviews (Onwuegbuzie & Frels, 2016, pp. 24)

The literature examined includes studies conducted in different countries where problem-BL and project-BL have been implemented. In some cases, ICT has been used to introduce this model. Include data for both schools in a low-income context and schools using ICT in the classroom was considered relevant.

2.2 CHALLENGES TO CONDUCTING THE LITERATURE REVIEW

The review reveals that a considerable body of literature has been published on PBL, primarily specific to higher education in medical school settings, but little research has been conducted on Kindergarten through 12th Grade (K-12) populations. There is a gap in the literature on problem-BL and project-BL implementation at the primary and secondary levels. This method presents an opportunity to equip students with 21st-century skills to prepare them to face real-world problems from young ages. Such a student-centered approach should not only be implemented after children have grown into adulthood (Tillman, 2013).

This literature review similarly draws attention to the fact that most theories on PBL were created in the past century to improve children's education, but most studies and pedagogical implementations have been executed in university settings. PBL is an active and student-centered approach, PBL prepares students for solving real-life problems (de Graaff & Kolmos, 2007). However, in a low-income context, it is a new challenge to integrate problem-BL and project-BL as an active learning model and ICT as a mediator allowing students to self-discover and self-motivate. This literature review, though, provides evidence that doing so is possible when teachers are trained

and equipped with the appropriate knowledge to alter traditional ways of teaching when they start to act as facilitators and successfully motivate students' curiosity to learn on their own.

2.3 RISE OF PROBLEM/PROJECT-BASED LEARNING IN HIGHER EDUCATION

During the 1960s, problem-BL originated at McMaster University in Canada and was introduced by medical student Howard Barrows (1985), who found a gap between theory and practice. Barrows observed that in professional practice, most doctors had forgotten what they learned as students and had difficulty treating patients. Barrows created a method that allowed students to combine theory and practice and named the method problem-based learning. *"PBL is the learning that results from the process of working toward the understanding or resolution of a problem. The problem is encountered first in the learning process. The problem is encountered first in the learning process!" (Barrows & Tamblyn, 1980 p. 1).*

Savin-Baden and Major (2004 p. 2) stated that PBL possesses the following characteristics:

1) Complex, real-world situations that have no one right answer are the organizing focus of learning.

2) Students work in teams to confront a problem, identify learning gaps, and develop viable solutions.

3) Students gain new information though self-directed learning.

4) Staff members act as facilitators.

5) Problems lead to the development of clinical problem-solving capabilities.

2.4 DIFFERENT APPROACHES TO PROJECT/PROBLEM-BASED LEARNING

According to De Graaf and Kolmos (2003), PBL places students at the center of knowledge and requires them to solve problems, work in teams, construct knowledge, and learn collaboratively. With PBL, teachers act as facilitators of the learning process, but students are the main actors. Margetson (1997, pp. 37-38) claimed that PBL is "a conception of knowledge, understanding, and education profoundly different from the more usual conception underlying subject-based learning. The difference can be seen in the notion of expertise." As stated in the guidelines of Servicio de Innovación Educativa Universidad Politécnica de Madrid (2008), PBL is a flexible strategy whose point of departure is the student; as the center of knowledge,

students can improve the quality of education they receive. Rongbutsri (2017) identified four approaches to implementing PBL: one-day projects, mini-projects, semester projects, and final-year projects.

PBL Models	Origin	Implementation time	Process that unfolded
One-day project	Singapore Polytechnic	One day per month, students meet in groups to work on an assigned problem within the context of a problem-solving template called problem theme.	Students spend all day solving problems assigned by their supervisors. They present their own solutions and get feedback from other groups, other students, and experts. Their supervisors assess and grade their work. One-day, one-problem assignments account for half of students' marks during the semester.
Mini-projects	Several universities integrating projects into their courses, known as mini-projects	Mini-projects take two to four weeks and can range from one-shot problem solving to a continuous program of solving the same problem throughout different stages of the course.	Mini-projects have set objectives, and students report on them using a simple document.
Semester projects	Bremen University in Germany, Roskilde and Aalborg in Denmark, and Twente in The Netherlands	Over one semester, such projects, assessed at the end of the semester, are worth 30%–50% of that semester's credits.	This project places students at the center of their learning. Students raise their own research problems. The problems are open, skeletal, and thematic, while supervision ensures that deep learning takes place. Students are expected to apply knowledge from current and past courses, and unanticipated outcomes are expected.
Final-year project	In some universities, students spend their final undergraduate year working on a large project that requires them to draw on all they have learned in their previous courses.	Over a year, students use all the knowledge and skills they have acquired to solve problems they have formulated. They may acquire new knowledge and skills. Reports are a component of the assessment.	Students may work individually or in groups with supervision. The underlying rationale is that students are capable of working on real-life projects.

Table 1. Summary of problem/project-based learning approaches based on Rongbutsri (2017)

These four types of PBL models have been implemented by various universities, and the time students spend on a problem can vary from one day to a year across universities.

2.5 ACTIVE LEARNING METHODS

According to Meyer and Jones (1993) "active learning involves providing opportunities for students to meaningfully talk and listen, write, read, and reflect on the content, ideas, issues, and concerns of an academic subject." Prince (2004) defined active learning as "any instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities and think about what they are doing." Problem-BL possesses these characteristics and is considered to be a form of active learning; however, there are other similar methods, such as project-BL, problem-solving and action learning.

Method	Organization of knowledge	Forms of knowledge	Role of students	Role of tutors	Type of activity
Problem-based learning	Opened-ended situations and problems	Contingent and constructed	Active participants and independent critical inquirers who own their learning experiences	Enabler of learning opportunities	Development of strategies to facilitate team and individual learning
Project-based learning	Tutor-set, structured tasks	Performative and practical	Completer of a project or member of a project team who develops a solution or strategy	Task setter and project supervisor	Problem-solving and problem management
Problem-solving learning	Step-by-step logical problem-solving through knowledge supplied by the lecturer	Largely propositional but may also be practical	Problem solver who acquires knowledge through bounded problem-solving	Guide for the proper knowledge and solution	Finding of a solution to a given problem
Action learning	Group-led discussion and reflection of actions	Personal and performative	Self-adviser who seeks to achieve personal goals and help others achieve theirs through reflection and action	Facilitator of reflection and action	Achievement of individual goals

Table 2. (Savin-Baden and Howell Major's,2004, p. 7) comparison of the forms of active learning

Active learning alters the rules of the traditional learning process. Knowledge functions are organized to stimulate students' discussion and solving of tasks and problems. This form of knowledge is practical but may be considered to be personal and performative depending on the method used. The teacher's role resembles that of a guide, facilitator, or project supervisor. Students self-direct the process of learning to achieve individual and group goals depending of the demands of the activity.

2.6 LEARNING PRINCIPLES OF PROJECT/PROBLEM-BASED LEARNING

Kolmos (2003) explained that PBL learning principles allow for variations in the development of PBL models and can be adjusted for a given institution. Special considerations should also be given to educational goals and social, cultural, political, and economic traditions, as well as educational and institutional cultures. The circumstances at Aalborg University, Delft University of Technology, or any other university can never be copied, but their concrete PBL models can inspire curriculum development in other parts of the world. De Graff, Kolmos, Du (2003; 2007; 2009, p.11) claimed that "there are common learning principles that cross PBL models and that can be captured in three approaches: learning, contents and social." De Graff and Kolmos (2003; 2007; 2009) developed a framework for higher education, taking as examples the two types at PBL universities in Europe.

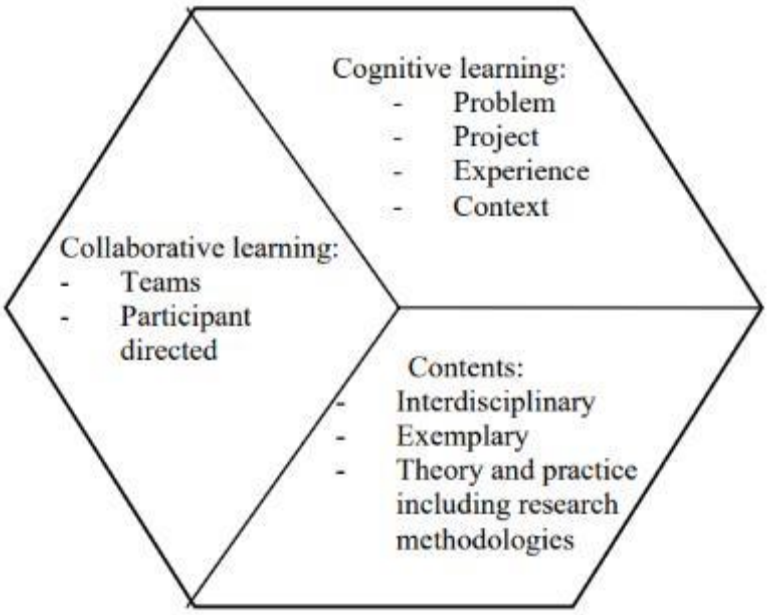

Figure 4. Problem/project-based learning principles proposed by (Kolmos, De Graff and Du,2009)

According to Kolmos, de Graff and Du (2009), the cognitive learning approach organizes learning around problems and carries out learning through projects. This is a central principle for the development of motivation. A problem (e.g., a wonder, anomaly, contradiction, or need) creates a starting point for the learning process, places learning in context, and bases learning on the learner's experience.

The contents approach concerns interdisciplinary learning, which may span traditional subject-related boundaries and methods. It is an exemplary practice in the sense that the learning outcome is an example of the overall objectives of the curriculum. The problem approach typically supports the relationship between theory and practice because the learning process involves an analytical approach applying theory to problems and problem-solving methods. This approach also provides training in research methodologies.

The social approach consists of team-based learning, which treats the learning process as a social act in which learning takes place through dialogue and communication. Students learn not only from each other but also from sharing knowledge and organizing the process of collaborative learning themselves. The social approach also encompasses participant-directed learning, which involves collective ownership of the learning process and, especially, problem formulation.

2.7 PROJECT/PROBLEM-BASED LEARNING IN PRIMARY EDUCATION

A considerable amount of literature has been published on problem-BL in higher education (de Graaff & Kolmos, 2003; 2007; 2009; Edwards & Hammer, 2006; Guerra, 2014; Jalkanen & Taalas, 2013; Kolmos, Holgaard, & Dahl, 2013; Savin-Baden & Major, 2004). However, literature reviews on PBL in primary education are scarce. More research on the K-12 population needs to be conducted because this method's effectiveness in primary school settings needs to be better known (Thomas, 2000; Tillman, 2013). Problem-BL and project-BL are challenges for primary school educators generally accustomed to implementing traditional methods that do not seem as difficult as PBL. According to Ronis (2008 p.45), "for many educators schooled in traditional K-12 teaching methods, implementing problem-BL may at times seem overwhelming. In the PBL process, teachers need to help learners build their own problem-solving skills and thinking abilities while teaching the content necessary to apply those skills. The fact of the matter, however, is that when the PBL process is broken down into steps, it can be easily applied for everyday teaching situation."

One objective of this literature review, therefore, was to suggest the problem-BL and project-BL model as a main reference for primary education. This model was developed by the Buck Institute for Education (BIE;2015), in California, United States, which has researched, trained, and implemented project-BL using Problem-BL as a departing point for twenty years, (Larmer et al., 2015). The BIE has used two

educational philosophers as its main references: William Heard Kilpatrick and John Dewey. The Project Method was introduced in a 1918 essay by Kilpatrick, one of Dewey's students, although, as Dewey believed, Kilpatrick's vision was too romantic and allowed students to freely decide the purpose of learning. Larmer et al. (2015, p. 27) discussed Dewey and Small: "Effective projects were carried out through a common enterprise in which the teacher became a partner in the learning process, guiding students to independently discover meaning within a subject area." Larmer et al. (2015, p.27) clarified that the gold standard project-BL developed by the Buck Institute differs from problem-BL despite some similarities: "We've found that many teachers describe the classic problem-based learning sequence when asked to describe the projects they're doing with their class." Larmer et. al (2015, pp. 33, 34)

BIE created the gold standard PBL framework, Larmer et.al. (2015, p. 34) using sixteenth-century Italy as a main reference. During this time, school architects, painters, and sculptors wanted to be recognized not only for their artisan skills but also their scientific and artistic knowledge. In 1577, under the patronage of Pope Gregory XIII, a school called the Accademia di San Luca was founded in Rome. Its assignments called *progetti* (projects) were used as a methodology for teaching and learning.

In my doctoral research, I have merged problem-BL and project-BL methods based on their similarities into a pedagogical model that allows integrating technology as a mediator to enhance students' knowledge through using technology for self-discovering and constructing knowledge. Problem-BL and project-BL have similarities because both are rooted in constructivism and Dewey's philosophy of education. Through both methods, students learn by solving questions, completing tasks, applying new and past knowledge, and developing skills necessary to succeed in the 21st century. Students build knowledge and are more independent when exploring assignments. Project-BL is better known in primary education than problem-BL.

Du et al. (2009, p. 20) argued, "the only way to transfer ideas from one culture or institution to another is by extracting the core learning principles. This has been done by defining the PBL learning principles." A model cannot be copied exactly from one culture to another, but a model can be used to inspire, and it is possible to develop a particular model to use in a particular context

Project Based Learning vs. Problem Based Learning	
Similarities	
Both PBLs: • Focus on an open-ended question or task • Provide authentic applications of content and skills • Build 21st century success skills • Emphasize student independence and inquiry • Are longer and more multifaceted than traditional lessons or assignments	
Differences	
Project Based Learning	**Problem Based Learning**
Often multi-subject	More often single-subject, but can be multi-subject
May be lengthy (weeks or months)	Tend to be shorter, but can be lengthy
Follows general, variously-named steps	Classically follows specific, traditionally prescribed steps
Includes the creation of a product or performance	The "product" may be tangible OR a proposed solution, expressed in writing or in a presentation
May use scenarios but often involves real-world, fully authentic tasks and settings	Often uses case studies or fictitious scenarios as "ill-structured problems"

Table 3. Project-based learning vs. problem-based learning (Larmer, 2014/2015)

Through both methods, students learn by solving questions, completing tasks, applying new and past knowledge, and developing skills necessary to succeed in the 21st century. Students build knowledge and are more independent when exploring assignments.

2.8 PHILOSOPHICAL STANDPOINT OF PROBLEM/PROJECT-BASED LEARNING

Problem-BL and project-BL both draw on the pedagogical model developed by Dewey's (1897) philosophy expressed in *My Pedagogic Creed*, which has five articles summarized as follows.

Article I—What Education Is. Children need to be stimulated in education to meet their social needs as group members interacting with other children for the sake of their own welfare.

Article II—What the School Is. According to Dewey's philosophy, "the school must represent present life as real and vital to the child as that which be carries on in the home, in the neighborhood, or on the playground." (p.7) School should be connected to children reality and train them to solve problems in a realistic way.

Article III—The Subject Matter of Education. Social activities play a dominant role in the subjects taught to students: "The true center of correlation on the school subjects is not science, nor literature, nor history, nor geography, but the child's own social activities." (p. 10)

Article IV—The Nature of Method. This article proposes four fundamental tenets: 1) Learning is an active process in which children are the center of knowledge. 2) The image is the great instrument of instruction. Students should participate in and connect with what they know and what they have learned. 3) Children's voices need to be heard by teachers: "Only through the continual and sympathetic observation of childhood's interests can the adult enter into the child's life and see what it is ready for." (pp.15) 4) The curriculum needs to include children's participation to offer them choices in their education: "The emotions apart from their corresponding activities introduce an unhealthy and morbid state of mind." (pp.15-16)

Article V—The School and Social Progress. Younger students should learn to understand their context and transform their society, so teachers must receive all the support necessary to become facilitators crucial to guiding children along their journey of self-discovery. "The business of everyone interested in education is to insist upon the school as the primary and most effective interest of social progress and reform in order that society may be awakened to realize what the school stands for and aroused to the necessity of endowing the educator with sufficient equipment properly to perform his task." (p.17)

Dewey is considered to be a progressive educator, comparable to Lev Vygotsky, Maria Montessori, and Jean Piaget, who all shared the core ideas that education should be child centered, students should be active learners, and their social contexts should be taken into consideration (Mooney, 2013). PBL is connected to constructivism, which holds that students should be provided with the proper tools to construct knowledge by themselves (Ronnis, 2008; Savin-Baden & Major, 2004). PBL draws from various cognitive theories claiming that the environment plays an important role allowing students to learn through guidance and collaboration (Bruner, 1996).

Authors	Main student-center characteristics	Key concepts
John Dewey (1916)	• Learning by doing • Experiential learning • Teaching to live in society	"'To learn from experience'" is to make a backward and forward connection between what we do to things and what we enjoy or suffer from things in consequence" (Dewey, 1916/2007 p. 117).
Maria Montessori (1914)	• Importance of the environment • Learning material and tools used in the classroom • Importance of teacher observation to understanding children's needs	"My method is scientific, both in its substance and in its aim. It makes for the attainment of a more advanced stage of progress, in directions no longer only material and physiological" (Montessori, 1914/1964 p. 8).
Jean Piaget (1929)	• Stages of cognitive development • Children discover knowledge	"The child's convictions are the product of a reaction influenced but not dictated by the adult" (Piaget, 1929 p.28).
Lev Vygotsky (1978)	• Zone of proximal development • Scaffolding: children learning with the assistance of adults or other peers • Learning as a social process	"That children's learning begins long before they attend school is the starting point of this discussion. Any learning a child encounters in school always has a previous history" (Vygotsky, 1978 p. 84).

Table 4. Forerunners of student-centered learning / Sources: Dewey (1902), Mooney (2013), Montessori (1914/1964), Piaget (1929), Vygotsky (1978)

2.9 PROJECT/PROBLEM-BASED LEARNING IN A LOW-INCOME CONTEXT

Halvorsen et al. (2012) conducted a study using a project-based approach with elementary students with low socioeconomic status (SES). The researchers used inferential statistics to compare achievement in social studies and content area literacy between students in low and high SES classrooms. This study found that the students in low SES settings could reach the same level of achievement as their high SES counterparts. Analysis of data from classroom observations and interviews found no significant differences in growth in low and high SES classrooms.

Implementing project-BL in communities with high poverty levels and historically low performance in social studies has been proven to improve reading and writing skills. The researchers formed two groups. In the experimental group, teachers with no previous experience teaching PBL were provided with a detailed plan for facilitating a class for which they instructed 80 social studies lessons over the academic year. In the control group, teachers taught social studies in a traditional way.

The researchers administered two assessments, one at the beginning of the study and one at the end of the study, to measure social studies, reading, and writing skills based on the state of Michigan's standards. Additionally, the researchers decided to assess another high SES school that used traditional teaching methods. This study claimed that project-BL was effective at fostering growth in both social studies and informational reading in the sample of second graders from high-poverty, low-performing schools during the first-year teachers implemented the approach (Duke & Halvorsen, 2017).

In another study, Giesige (2017) proposed using project-BL as an alternative method in high-poverty, low-income schools. Giesige (2017, p.1) criticized teacher-centered education and pointed out that a "pedagogy of poverty" had been implemented in poor public schools. The term "pedagogy of poverty" was first used by Haberman (2010, p. 83), who argued that "the classroom atmosphere created by constant teacher direction and student compliance seethes with passive resentment that sometimes bubbles up into overt resistance."

According to Gorski (2013), teaching in poverty is a challenge, but educators should change their attitudes toward children from low-income families and seek to boost students' potential regardless of their economic and social backgrounds. If students from unprivileged areas receive support from teachers and peers, they may be more likely to succeed in school; there is currently no evidence that supports the contrary (Jensen, 2009).

2.10 INFORMATION COMMUNICATION TECHNOLOGY AND PROJECT/PROBLEM-BASED LEARNING

Integrating ICT tools, such as computers and the Internet, into an active pedagogical model, such as PBL, can have positive impacts on student learning. It is important to work on teachers' beliefs regarding ICT use and pedagogy because if they do not believe these methods can improve students' learning, teachers will be reluctant to implement active techno-pedagogical approaches (Richards, 2005).

Richards (2005) claimed that the use of technology in the classroom produces different results with a student-centered approach because children learn for the purpose of discovering and constructing knowledge and abandon their passive roles. Integration of ICT and problem and project-BL must be connected to the curriculum and build teachers' capacities to use the Internet and other tools that may increase children's ability to learn rather than merely memorize content.

In a study by Asan and Haliloglu (2005), project-BL was introduced into a computer class of sixth-grade students at a Turkish elementary school. The control group of 50 students received traditional instruction, while the experimental group of 48 students received PBL instruction. The results related to PBL were positive, according to the

researchers, (p.77) “PBL allows the computer teacher the flexibility to present their curriculum in an innovative manner. In the PBL, the teacher becomes a facilitator, a consultant or guide on the side, helping students to access, organize and obtain information.” The authors supported their findings by citing observations by Venville, Wallace, Rinnie, and Malome (2000) “that students’ learning was enhanced as a result of the collaboration and communication between the students of the pairs. Students were able to research relevant science and math concepts that were, at times, beyond the expertise of the teacher. Also, students developed ideas for further research and study as a result of the team project.” Asan & Haliloglu (2005, p. 68)

A study conducted at the Latin American Complutense School in Puebla, México, found that the integration of technologies, PBL and collaborative learning provide significance benefit in classroom practice (Saez-López & Ruiz-Ruiz, 2012). The researchers recommended PBL, collaborative learning, and ICT to increase student participation using different interactive technologies, such as digital blackboards, Skype, webinars, wikis, PowerPoint, and Prezi, among others.

In another study conducted at the Universidad de Malaga in Spain, Benítez, Cruces, De Haro, and Sarrión (2010) demonstrated the use of a virtual platform to introduce problem-BL. They developed a model relating the different phases of PBL to resources and campus virtual activities capable of facilitating tasks. Table 5 presents a sample from the original work written in Spanish by Benítez et al. (2010), which describes the PBL phases and characteristics, as well as Moodle resources.

Problem/project-based learning Phases	**Steps**	**Moodle Resources**
Reading and analyzing the problem	The students gather in working groups in both synchronous and asynchronous modes and assess all they know. The topic of study is raised by the teacher. The students identify the terms and relevant aspects, create hypotheses, and discover the objectives of the study.	Forum Chat Wiki Instant message Internal e-mail

Table 5. Sample of problem/project-based learning implementation using information communication technology / Source: Spanish-language sample table by Benítez et al. (2010)

Integration of problem-BL, project-BL, and ICT implies that the organization of lessons takes into consideration aspects such as collaboration, teamwork, research, self-discovery, and critical thinking. The use of computers and the Internet can open access to many resources that the teacher must choose strategically to ensure that students can connect what they learn with reality.

2.11 CONCLUSIONS

According to this literature review, the main constraints to applying problem-BL and project-BL include teachers' lack of training in this pedagogical approach and limited access to appropriate technology and infrastructure. Most studies on PBL have agreed that once these aspects are overcome, PBL implementation can be highly successful, even with elementary students from both high and low SES school. BIE's (2015) model based on Dewey's and Kilpatrick's philosophies is gaining more recognition among elementary school teachers, especially in the United States.

The use of ICT as a mediator for introducing PBLs presents an opportunity for teachers to motivate their students to become active learners. Teachers play a key role as facilitators, and it is important to train them in a way that alters their traditional mindsets. The appropriate use of technology and pedagogy may bring about positive results, even in schools in low-income areas. However, more studies are needed to deepen understanding of the contradictions inherent in shifting from a traditional (teacher-oriented) pedagogy to active (student-oriented) learning in schools in impoverished areas

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CHAPTER 3. RESEARCH DESIGN, METHODOLOGY, AND THEORETICAL FRAMEWORK

In this chapter, I outline the research design, the methodological approach used to develop this research, and the theoretical framework underpinning this study. I explain the philosophical and scientific positions adopted in this study, the methods and theories used to analyze the data, and my role as researcher.

3.1 OVERALL RESEARCH DESIGN

Figure 5 presents my research process based on Saunders, Lewis, and Thornhill (2009). In the literature review, I identified the most frequent paradigms and decided which to adopt based on the goals of this research. I employed an inductive approach using the research questions and data collected in the fieldwork to generate the hypothesis, so this study can be defined as design study. This mono-method, qualitative, cross-sectional study focused one case, studying the phenomenon at once specific time.

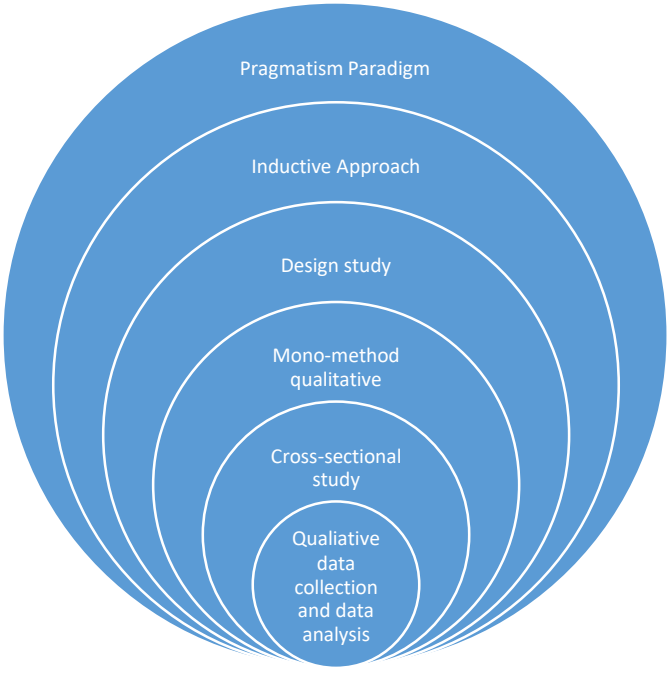

Figure 5. Overview of the research design of the study based on Saunders et al. (2009)

3.2 PARADIGM ADOPTED

A research paradigm is "a basic set of beliefs that guide action." (Guba, 1990, p. 17). Creswell (2014) believed that philosophical ideas influence the practice of research and need to be identified. He used the term worldview to refer to paradigms and to highlight four widely discussed in the literature.

Post positivism	**Constructivism**
Determinism Reductionism Empirical observation and measurement Theory verification	Understanding Multiple participant meaning Social and historical construction Theory generation
Advocacy/Participatory	**Pragmatism**
Political Empowerment issue oriented Collaborative Change oriented	Consequences of actions Problem centered Pluralistic Real-world practice oriented

Table 6. Four worldviews / Source: Creswell (2014)

The research paradigm of pragmatism was adopted in this research because it allows responding to "what" and "how" questions related to the research problem (Creswell, 2003). This inquiry paradigm helps to analyze and look for solutions to real-world problems involving human activity (Morgan, 2014; Powell, 2001). According to Guba and Lincoln (1994), the inquiry paradigm defines what inquirers are about and what falls within and outside the limits of legitimate inquiry. These paradigms respond to fundamental ontological questions about the form and nature of reality; epistemological questions "about the nature of the relationship between the knower or would-be knower and what can be known"; and methodological questions about how can the inquirer (the would-be knower) can find what they believe can be known. Although not among the philosophical assumptions in Guba and Lincoln's (1994) inquiry paradigm, axiology was relevant to this research. As Denzin and Lincoln (2005; see also Klenke, 2008, p. 18) stated, "values are a part of the 'basic beliefs' that undergird and affect the entire research process: choice of problems, guiding paradigm, rhetorical framework, data-gathering method, analysis strategy, and even the presentation format of the finding."

Research paradigm	What does it mean to my research?
Ontology	This study has a subjective approach to reality and posits that "there is not a single truth"; instead, the context shapes reality.
Epistemology	In this emic approach, the researcher interacts with practitioners to identify and find a useful way to solve a problem.
Axiology	Change is the value of this research, which is aimed at transforming traditional teaching practices through the interactions of the researchers and the practitioners.
Methodology	Education design research was the methodology used in this study (McKenney & Reeves, 2012). It describes a family of approaches aimed at the dual goals of developing theoretical understanding useful to others and designing and implementing interventions to address problems in practice.
Method	This study follows a qualitative approach method.

Table 7. Characteristics of the pragmatic paradigm applied in the research

Table 7 presents the five fundamental questions of the pragmatic paradigm (Denzin & Lincoln, 2005; Guba & Lincoln, 1994), and I also incorporated the method to respond to the kind of approach used in this study. In the next section, I explain in greater depth the methodology, methods, and theories used to analyze the data.

3.3 METHODOLOGY

A methodology is defined as the strategy or plan of action linked to the research questions and methods (Cresswell, 2003). The researcher is an inquirer determining what it is necessary to be known; therefore, not any methodology is appropriate for a particular study (Guba & Lincoln, 1994). This research was intended to design a learning model for collaborative use with practitioners in the classroom and to develop theoretical understanding of the research problem. The methodological approach used was based on design-based research (DBR). According to a group of learning sciences researchers called Design-Based Research Collective (2003, p. 5), good DBR exhibits the following five characteristics: "First, the central goals of designing learning environments and developing theories or 'prototheories' of learning are intertwined. Second, development and research take place through continuous cycles of design, enactment, analysis, and redesign (Cobb, 2001; Collins, 1992). Third, research on designs must lead to sharable theories that help communicate relevant implications to practitioners and other educational designers (Brophy, 2002). Fourth, research must account for how designs function in authentic settings. It must not only document success or failure but also focus on interactions that refine our understanding of the learning issues involved. Fifth, the development of such accounts relies on methods that can document and connect processes of enactment to outcomes of interest." Anderson and Shattuck (2012), Bannan-Ritland (2003), Jen, Moon, and

Samarapungavan (2015), Kelly, Lesh, and Baek (2008), and Plomp and Nieveen (2009) pointed out that DBR is a well-known methodology used in educational research.

3.4 EDUCATIONAL DESIGN RESEARCH

The study methodology selected was EDR, a term used to describe a family of approaches to achieve the dual goals of developing theoretical understanding useful to others while designing and implementing interventions to address problems in practice (McKenney & Reeves, 2012). EDR thus is another name for DBR (Kolmos, 2015). It takes a pragmatic orientation to the world and allows the problem and research questions to determine the methodology. Design researchers also have double challenges, using different methods to accomplish theoretical understandings and practical solutions to problems.

The design principles guiding this research met these criteria and were based on the general model proposed by McKenney and Reeves (2012; see Figure 6). Each phase used different kinds of methods and required making choices during the research process. In the following section, I explain each phase of the research and the methods and data analysis used.

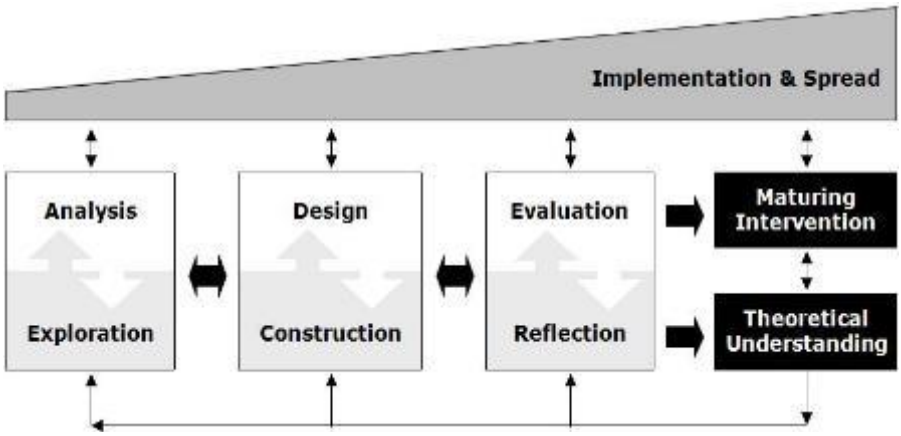

Figure 6. Generic educational design research model comprising three phases (McKenney & Reeves, 2012)

Using EDR as the research methodology helped me to organize the study into three phases and choose the appropriate methods to collect and analyze the data. Table 9 presents the methods selected for the analysis and exploration phase of the research, while Table 10 shows the methods used during the evaluation and reflection phase. It is important to clarify that during the design and construction phase; no new data were required.

3.4.1 RATIONALE FOR CHOOSING EDR AS METHODOLOGICAL APPROACH

EDR is a methodology covering theory and practice, contributing in two ways, "one to fundamental understanding (theory), and the other to applied use (and intervention that solves a problem in practice)" (McKenney & Reeves, 2012, p. 31). EDR allows me to reach two goals: to contribute with a theoretical understanding of the current situation to an underprivileged school located in an impoverished setting struggling with socioeconomic problems and high criminality rates, and at the same time to contribute to improving quality of education with practical solutions at a micro level.

EDR is a flexible methodology, so I can pursue my research goals to create change in a real-world context and collect data to analyze the situation, working along with key stakeholders such as teachers, school authorities, students, and technology providers such as the Zamora Teran Foundation. EDR provides a generic model (McKenney & Reeves, 2012) shown in Chapter 3, Figure 6, that facilitates the creation of a roadmap to organize, manage, and classify the data collected during the research timeframe.

Van den Akker, Gravemeijer, McKenney, and Nieveen (2006, p. 4) characterized EDR as interventionist, iterative, process-oriented, utility- and theory-oriented, based on the work of other authors who they cited: Cobb, Confrey, diSessa, Lehrer, and Schauble, 2003; Kelly, 2003; Design-based Research Collective, 2003; Reeves, Herrington, and Oliver, 2005; van den Akker, 1999. In Table 8, I summarize how each of those EDR characteristics are related to my research scope.

EDR Characteristics (van den Akker, et al. 2006):	My research characteristics:
Interventionist: The intervention is carried out in a real-world context, trying to solve complex problems.	The research is conducted in a public school located in a deprived area, in collaboration with practitioners seeking solutions to improve pedagogical and technological constraints.
Iterative: "The research incorporates a cyclic approach of design, evaluation and revision" (p. 4).	This design is refined in different classrooms with teachers and students to come up with the final evaluation of the prototype design.
Process-oriented: It pays more attention to the steps that are followed during the intervention with the aim to improve the design of the intervention.	The prototype lesson is examined in the classroom in collaboration with practitioners and students in order to respond to what and how to improve the pedagogical practice in order to shift from a teacher-oriented method to a student-centered approach using ICT.
Utility-oriented: "Users measured the practicality of the design in real context" (p. 4).	Teachers and students are the main users and they will evaluate the practicality of using this design in the classroom.

Theory-oriented: "The design is (at least partly) based upon theoretical propositions; and field testing of the design contributes to theory building" (p. 4).	The design proposition is based on PBL principles, inspired by a student-centered approach, it considers the development of 21st-century skills through the use of ICT in the classroom.

Table 8. presents EDR characteristics related to this research scope (van den Akker et al., 2006)

Besides possessing the characteristics outlined above, also I consider that EDR is appropriate to this study because it meets the following requirements described in Brown (1992) and Collins (1992) and cited by Herrington, McKenney, Reeves, and Oliver (2007): "addressing complex problems in real contexts in collaboration with practitioners; integrating known and hypothetical design principles with technological affordances to render plausible solutions to these complex problems; and conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles."

3.4.2 REFLECTION ON MY CHOICE OF METHODOLOGY

I have selected EDR (McKenney & Reeves, 2012) as my research methodology for the following reasons: firstly, this methodology provides me with a framework that allows me to conduct my research from beginning to end following three main phases: Analysis and exploration; design and construction; and evaluation and reflection. In each phase I have the opportunity to choose the right methods for data gathering and to define the appropriate theories to analyze the data collected.

Secondly, EDR focuses on the design, development, and evaluation of educational intervention, in collaboration with practitioners. My research aims to co-design a lesson prototype following PBL principles and integrating ICT as a means. Also, I look to examine the current situation in the school context and make changes at a micro level, proposing new ways to improve the learning process in the classroom (Valverde-Berrocoso, 2016).

Thirdly, besides my roles as researcher and designer, I expect to have a role as facilitator, training the teachers on PBL principles, and providing them the pedagogical skills to manage a student-centered approach in the classroom and to integrate a problem-project based learning approach into their lesson plans that allows them to use XO computers as a means to equip students with 21st century skills (McKenney & Reeves, 2012).

Fourthly, the flexibility of EDR for working with different stakeholders—in this case with teachers, school authorities and the Zamora Terán Foundation—gives me the opportunity to search for solutions to the problem in collaboration with them. EDR

provides the target group of this research voice and choice, and the practitioners play an active role in building solutions. As a Ph.D. student, I want to conduct my research project in a real context, using learning theories as a guide to help me navigate the complexity of my research goals and becoming involved with practitioners from the beginning of the study, since the practitioners are the only ones who work in this context on a daily basis and who will continue working there after I finish my research (Amiel & Reeves, 2008).

As Herrington et al. (2007) claim:

> "*Following a design-based research study, doctoral students will be seen by practitioners as partners with whom they do research, as opposed to hypothetical beneficiaries of their research. They also learn from the earliest days of their doctoral programs that education is not a form of human activity that is susceptible to natural laws in the way that some other more biologically based practices are."* p. 409

Finally, using EDR will help me to bridge the gap between theoretical understanding and practical applications in the classroom setting in a school located in an impoverished context. As Kolmos (2015) points out, DBR has been a methodological choice for many Ph.D. students and there is "no doubt that DBR can connect theory and practice – and can change practice." However, she claims that "the use of DBR requires resources and abilities to handle both academia and practice."

3.4.3 ANALYSIS AND EXPLORATION

This first phase consisted of conducting a literature review and getting an initial orientation to define the problem (McKenney & Reeve, 2012; Chapter 2). The best way to explore and understand the context in which a classroom design lesson was conceived was for researchers and practitioners to work together to produce an artifact that met real-world requirements without jeopardizing the methodological quality of the research (van den Akker, 2006). During the analysis, I selected qualitative research methods as the type of scientific research that would allow me to understand the problem and the context (Mack & Woodsong, 2005). In the exploration, I followed empirical research because "empiricism is the process of learning things through direct observation or experience, and reflection on those experiences" (Goodwin, 2010 p.7). During the exploration, the fieldwork was essential to understand the context. I scheduled meetings with the school principal, teachers from first to sixth grade, and the executive director of ZTF, who was part of the training agenda. In the next section, I present the analysis and exploration methods used.

3.4.4 DATA GATHERING AND ANALYSIS METHODS

In the analysis and exploration phase, I used different qualitative methods to collect and analyze the data. According to Mack & Woodsong (2005, pp 1-2) "Qualitative methods are also effective in identifying intangible factors, such as social norms, socioeconomic status, gender roles, ethnicity, and religion, whose role in the research issue may not be readily apparent."

Analysis Phase	Exploration Phase	Data Analysis
Methods	**Methods**	**Theory**
• Informal meetings • Literature Review • Classroom observation • In-depth interviews with teachers • Survey of students • In-depth interviews of principals	• Future workshop (Jungk & Müllert, 1987) • Visual anthropology (Collier & Collier, 1986)	• Theory of constraints (Goldratt, 1990) • Pedagogy of the oppressed (Freire, 1970)

Table 9. Data gathering and analysis methods in the first phase of EDR

This first phase of analysis and exploration helped to conceptualize the problem, providing inputs from practitioners and students. I used different methods (Table 9) to obtain deep insights into the overall context of the study.

Informal Meetings

During the analysis of the situation, informal meetings were held with the teachers, school administrators, and ZTF staff.

Literature Review

The literature review presented in chapter 2 examined the problem from a theoretical perspective and set the boundaries of the scope of the study.

Participant Observation

I participated as an observer in the school classroom setting using semi-structured format (see Appendix A). "Being a participating member of the group can give the researcher first hand insights that remain hidden to a more remote observer" Goodwin & Goodwin (2017, pp. 291) Patton (2002, as cited in Hadzilias, 2011) outlined the dimensions of observation:

1) Role of the observer: full participant to spectator

2) Perspective: insider to outsider

3) The person who conducts the inquiry: professionals to people in the setting studied

4) Disclosure of the observer's role: full disclosure to no disclosure

5) Duration of observations: a short, single observation to long-term, multiple observations

6) Focus: a single element to a holistic view of the setting

In-depth Interviews

I conducted in-depth interviews with the teachers and school administrators (see Appendix B). In the analysis and exploration phase, I selected two teachers and the school principal to interview. I used an audio recorder and a video camera to collect data. "In-depth interviewing is a qualitative research technique that involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program, or situation" (Boyce & Neale, 2006 p.3).

Survey

I administered a qualitative survey to 21 children to learn more about the socio-economic background of the target group (see Appendix C). A survey is a structured set of questions or statements given to a group of people to measure their attitudes, beliefs, values, or tendencies to act. (Goodwin, 2010, p. 463).

Socratic Method

The Socratic method is used to motivate participants to engage and participate in an open dialogue and seeking solutions to the questions by themselves. (Goldratt, 1990) Ideas for improving and generating change come from practitioners, there is no need to bring an expert from outside the organization.

Future Workshop

A future workshop "is a technique to reflect on a common problematic situation, generate a vision about the future, and to discuss how these visions can be realized." (Valqui-Vidal, 2006, as cited in Purushonthaman, 2011, p. 4). I chose to use the future workshop method because it facilitates seeking joint solutions to problems from a

democratic perspective. In this technique, I had the role of workshop facilitator, guiding the participants through different phases and working with ZTF, the main provider of XO computers and technical support for the school. (see Appendix D).

As described on Chapter 4, I carried the five phases of future workshops proposed by Jungk and Müllert (1987) and Valqui-Vidal (2006, p 5):

1) Preparation phase: The workshop organizers and facilitators set the themes, invited participants, methods, rules, and timetable, room, and local facilities of the workshop.

2) The critique phase: "The problem is critically and thoroughly discussed and investigated. Brainstorming is the preferred creative technique", followed up with "structuring and grouping of ideas" into main sub-themes.

3) Fantasy phase: The participants describe "a utopia to draw an exaggerated picture of the future. Brainstorming and other creative technique might be used." The participants' social fantasies "are developed in this phase."

4) Implementation phase: The "ideas found are checked," and their practicality evaluated. "An action plan is elaborated."

5) Follow-up phase: "The action plan is monitored", changes are made, and if needed, new FWs are planned.

Visual Anthropology

"Visual anthropology is useful for ethnographic research, media analysis, and studies of material culture. Visual anthropology also encompasses the anthropological study of representation, including areas such as performance, museums, art, and the production and reception of mass media" (Vaughn & Englert, 2010, p. 906). I choose visual anthropology as a method to explore the external and internal context in which the school operates. The photographs presented in Chapter 4 help map out the following aspects to examine the school`s context (Collier & Collier, 1986):

1) Location: the area and the geographical features of the school

2) Appearance: the type of building, streets, wall, and surrounding neighborhood

3) People: those who live around and pass by the school, transportation, and how students, teachers, and parents reach school;

4) Daily cycles: the flow of people around the school, the peak of activities, socioeconomic status, school infrastructure, educational supplies, and technology support

Photographs of the outside of the school were captured with a cell phone to avoid attracting attention because the area had a high crime rate. The photographs inside the school were taken with a video camera rather than recorded to ensure good-quality photos. I captured activities that developed naturally, avoiding posed photos.

3.4.5 DESIGN AND CONSTRUCTION

Design and construction are considered to be a micro-cycle of the EDR generic model. "The use of micro phases or prototyping phases in DBR is a strategy to ensure reliability of the design before the final field work study" (Kennedy-Clark, 2013, p 116). Design requires time to reflect and generate ideas to seek solutions based on the data gathered and to support the results with the literature review and theoretical framework from the previous phase (McKenney & Reeve, 2012; McKenney, S., Nieveen, N., & van den Akker, J., 2006).). In this research, the previous phase provided inputs to determine the needs of the teachers, students, school principal, and ZTF staff director using different methods, which were important aspects to take into account to construct a model. Figure 7 describes the general process I followed in the design and construction phase, which is explained in more detail in chapter 6. The prototype was tested in the next phase.

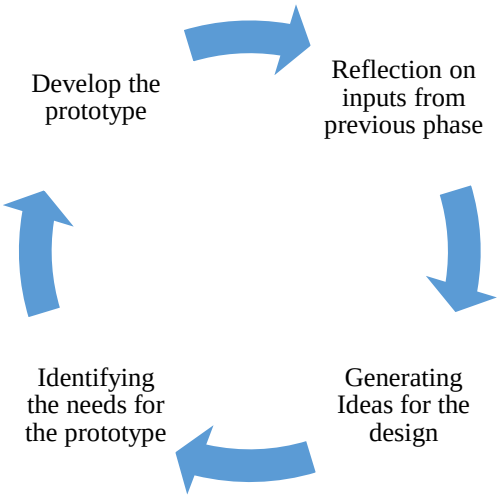

Figure 7. General process of design and construction (McKenney & Reeves, 2012)

3.4.6 EVALUATION AND REFLECTION

In this phase, I connected theory and practice and tried out the prototype co-designed and constructed in collaboration with the teachers, who supported this research with their everyday practice. The term *evaluation* refers to testing of the prototype, and *reflection* to thoughtful analysis of the implantation (McKenney & Reeves, 2012). Table 10 presents the different methods used to collect the data defined in section 3.5.1 and unfolded in Chapter 7.

Evaluation	Reflection	Data Analysis Theory
• Tryout in the classroom setting	• In-depth interviews with teachers • In-depth interviews with students • Classroom observation	• Theory of constraints (Goldratt, 1990) • Pedagogy of the oppressed (Freire, 1970) • Activity theory (Engeström, 1968)

Table 10. Chosen data gathering and analysis methods

The data collected during the empirical work was qualitative and represented the interactions between the teachers and students in the classroom during the implementation of the prototype lesson design. After the teacher training in PBL during the first phase, the principal and the ZTF director choose two teachers who met the following criteria: they showed positive attitudes toward the development of training in this study. Although not a daily basis, the third- and fifth-grade Spanish teachers used XO computers to help students improve their reading and writing skills, one of the main weaknesses of the Honduran educational system, according to a report from Progreso Educativo Honduras (2017). The children participating in the study belonged to the classes of the chosen teachers.

3.4.7 PROCESS OF CO-DESIGNING AND CONSTRUCTING THE PROTOTYPE

Before the implementation phase, the process to co-design and construct the prototype was confirmed based on practitioners' views. They were taken into consideration from the beginning of the study until the final stage, with the aim to change top-down practices in the classroom and implement more student-oriented practices integrating ICT in the prototype lesson design (Figure 8).

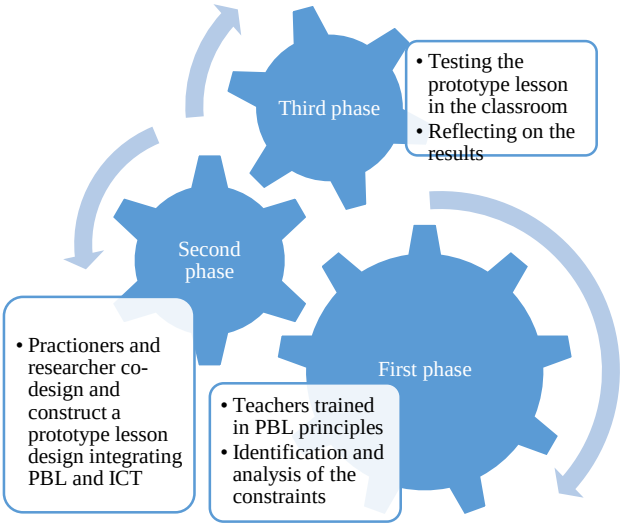

Figure 8. Development of the prototype lesson design following the phrases of education design research

3.5 ANALYSIS OF COLLECTED DATA

According to Aneshensel (2015, p. 3) "the term data refers to a body of raw or unorganized information that has been collected together for the purpose of analysis, drawing conclusions, or making decisions." Furthermore, Aneshensel points out "by itself, a set of data is just an accumulation of numbers signifying bits and pieces of information. Its nature must be comprehended. This understanding is accomplished through data analysis, which is the systematic arrangement of information into intelligible patterns." (2015, p. 4).

3.5.1 PROCESS OF DATA ANALYSIS

I used different kind of methods to collect the data, as shown in Table 9 on data gathering and analysis methods in the first phase of EDR and Table 10, on chosen data gathering and analysis methods in the evaluation and reflection phase. I adopted the six phases of thematic analysis proposed by Braun and Clarke (2006, p. 87) to conduct the data analysis: Familiarizing yourself with your data; generating initial codes; searching for themes; reviewing themes; defining and naming themes; producing the report. (Braun and Clarke, 2006 as cited in Mortensen, 2019)

"Thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data. It minimally organizes and describes your data set in (rich) detail." (Braun and Clarke, 2006, p. 79)

1) Familiarizing yourself with your data

According to Erlingsson and Brysiewicz (2017, p. 93) “A common starting point for qualitative content analysis is often transcribed interview texts. The objective in qualitative content analysis is to systematically transform a large amount of text into a highly organized and concise summary of key results.” I transcribed the verbal data from the interviews that I recorded in videos, tape-recorded and field notes. The process of transcribing was first listening to all the interviews and writing down the selected part to be used in this study, however, I had to listen to the interview many times to interpret the interviewee's responses.

I practiced semi-structured interviews with teachers and the school`s principal and children. I also applied a qualitative survey with children and took a sample of the children`s population participating in this study. I processed this data and used it to understand the children's context. Another important data came from a future workshop, practiced participant observation and used field notes as well, I transcribed. I used the photograph data as well and followed the steps suggested by Collier and Collier (1986) for analysis.

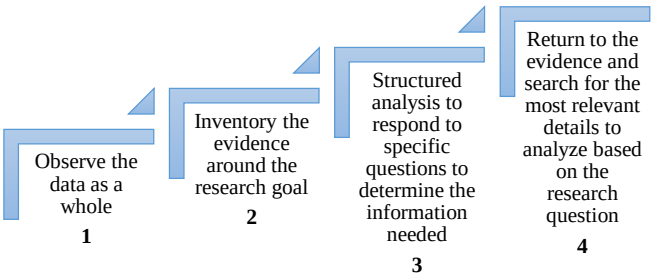

Figure 9. Steps of the analysis of photographs (Collier & Collier, 1986)

2) Generating Initial Codes

This study uses directed content analysis approach as a qualitative research technique, since this research starts with theory and the codes are defined before and during data analysis; codes are derived from data Kyngas&Vanhanen,1999 (cited in Hsieh, & Shannon, 2005, p.1286).

Type of Content Analysis	Study starts with	Timing of Defining Codes or Keywords	Source of Codes or Keywords
Conventional content analysis	Observation	Codes are defined during data analysis	Codes are derived from data
Directed content analysis	Theory	Codes are defined before and during data analysis	Codes are derived from theory or relevant research findings
Summative content analysis	Keywords	Keywords are identified before and during data analysis	Keywords are derived from interest of researcher or review of literature

Table 11. : Three approaches to content analysis (Hsieh & Shannon, 2005)

I used theories to develop the initial coding, as explained in sections 3.7 and 3.8. The TOC (Goldratt, 1990): three thinking process tools (effect–cause-effect, evaporating clouds, and the Socratic method); and the pedagogy of the oppressed (Freire, 1970), as a critical pedagogy to identify the core problems. I linked different theories with collected data as shown in chapters four, five and six.

According to Erlingsson and Brysiewicz (2017, p. 94) "A code can be thought of as a label; a name that most exactly describes what this particular condense meaning unit is about. Usually one or two words long." For example, participants in future workshop defined codes and during the interview process, they mentioned words such as Internet, software, teacher, training, children, infrastructure, XO computers and equipment, school absences.

Figure 10. Teachers help identify codes before analyzing the data collected in the interviews and future workshop

3) Searching, reviewing and defining for themes

While searching for themes, I sorted different codes from the list that I identified across the data and this became potential themes, I categorized them, "category is formed by grouping together those codes that are related to each other through their content or context." (Erlingsson and Brysiewicz, 2017, p. 94)

I reviewed and defined the themes, "a theme can be seen as expressing an underlying meaning, i.e., latent content, found in two or more categories. Themes are expressing data on an interpretative (latent) level. A theme answers questions such as why, how, in what way, or by what means?" (Erlingsson and Brysiewicz, 2017, p. 94)

I used theory to define the themes for instance in chapter five I presented in Table 22 identified categories in my research that are described by Freire (1970) e.g. teachers teach and the students are taught, I used these categories to study the effects caused in a teaching-oriented method and the usage of XO computers in the classroom.

4) Producing the report

Braun and Clark (2006, p. 93) recommend to choose "vivid examples, or extracts which capture the essence of the point you are demonstrating, without unnecessary complexity. The extract should be easily identifiable as an example of the issue." From my data I seek to build a narrative with the data beyond just describing, for instance, in chapter 5, I extracted and analyzed the data using learning theories:

> Teacher: "What do you think the brain is? Please, listen." Some students tried to answer at the same time, and the teacher asked one girl to speak up.
>
> Student: "When someone pulls my hair, my brain hurts"

> Teacher: “But ... what is the brain?” Suddenly, the teacher moved from teaching to disciplining and spoke loudly. “Let’s see, you guys in the back, what's happening there?” Those students were not paying attention to the class at all.
>
> This classroom management emphasized a behavioral approach, and the teacher tried to control the class by keeping the students quiet and paying attention. The relationship between the teacher and students was top-down. There are connections between banking education (Freire, 1970) and the behaviorist learning of theory (Skinner, 1974).

In sum, choosing thematic analysis as a method to interpret my data was a good option to respond to my research questions. “What is important is choosing a method that is appropriate to your research question, rather than falling victim to ‘methodolatry’, where you are committed to method rather than topic/ content or research question” Holloway and Todres, 2003 (in Braun and Clark 2006, p. 97)

3.6 MULTIPLE ROLES: AS RESEARCHER, DESIGNER AND FACILITATOR

I had triple roles as researcher, facilitator and designer. As McKenney and Brand-Gruwel (2015) stated, “we distinguish three different and crucial roles that design researchers play as they interact with practitioners throughout entire projects, and within specific phases: consultant/facilitator, designer, and researcher.” In Table 12, I describe the multiple roles I performed during this study looking for solutions from practical and theoretical perspectives.

Figure 11. Practitioners and the researcher in her role as a facilitator

Role	Analysis and Exploration	Design and Construction	Evaluation and Reflection	Implementation and Spread
As researcher	• Understanding the research problem • Planning the research methodology • Unfolding the research process with different stakeholders	Finding solutions to the identify problem by interpreting the data collected during the empirical work and the literature review	Implementing and testing a design to develop practitioners' skills to introduce the principles of student-center pedagogy	• Supporting implementation by a selected group of teachers and students • Observing how the design is applied in the classroom • Analyzing the data
As designer		• Crafting tools to use during the field investigation • Designing • the intervention taking into consideration the data collected • Co- designing a prototype lesson with practitioners	Reviewing and co- designing the lesson with practitioners	
As facilitator	• Facilitating workshops on PBL to practitioners • Facilitating a future workshop to identify the constraints			Facilitating reflection on the outcomes of the implementation

Table 12. Description of the researcher's multiple roles

I performed different tasks during the phases: a researcher in all phases; a designer during the design and construction phase and the evaluation and reflection phase; and a facilitator during the analysis and exploration phase and the implementation and dissemination phase.

3.7 THEORETICAL FRAMEWORK OF THE RESEARCH

Performing the literature review presented in Chapter 2 provided a theoretical understanding of the research questions. It clarifies the scope of the investigation, allowing me to develop a theoretical framework relevant to collecting and analyzing the data.

3.7.1 OVERVIEW OF DEWEY'S CREED

As pointed out in Chapter 2, the theoretical background for this research was based on student-centered learning. As the main reference, I took John Dewey, considered to be a pioneer of learning by doing. In his book *My Pedagogical Creed*, Dewey (1897, pp. 11) declared, "I believe that the school must represent present life—life as

real and vital to the child as that which he carries on in the home, in the neighborhood, or on the playground."

Dewey believed that "the school may be connected with life, commonplace way is carried over and made use of there, and what the child learns in the school is carried over and made use of there, and what the child learns in the school is carried back and applied in everyday life, making school organic whole, instead of a composite of isolated parts." Dewey (1990, pp.55)

Dewey's theory of learning conflicted with traditional ways of teaching. He promoted and was the main leader of the progressive education movement. His ideals were deeply rooted in democratic and pragmatic views shaped by the first industrial revolution in the United States. Dewey's approach was child centered and connected multiple subjects, giving the teacher a role as more a facilitator than an instructor.

3.7.2 A MODEL BASED ON DEWEY'S PRINCIPLES

In my research, I found a model based on Dewey's principles of teaching developed by the BIE (2015), a non-profit organization founded in 1987 with the aim to expand the effective use of project-BL throughout the world. Based in Novato, California, United States, BIE created" a comprehensive, research-based model for PBL—a 'gold standard' to help teachers, schools and organizations to measure, calibrate their practice" (Solis, Larmer, & Olabuenaga, 2015, pp. 54).

Larmer et al. (2015, pp. 33) recognized that gold standard project-BL "can be subjected to critique, debate, and reformulation." However, BIE have improved and adjusted this model more than 40 times. It has three parts: 1) student learning goals; 2) essential project design elements; and 3) project-based teaching practices (Solis et al., 2015, pp. 54). Figure 12 describes the essential project design elements of gold standard project-BL, while Figure 13 describes project-based teaching practices.

This research is inspired in the gold standard model and used as the framework of my study (figures 12 and 13) to introduce problem- BL principles using a project-oriented pedagogy and to enhance the integration of ICT and 21st-century skills into the classroom (BIE, 2015).

Figure 12. . Copyright ©2015 Buck Institute for Education. Gold standard project-based learning: Essential project design elements (Lamer et al., 2015, pp.34)

I elaborated the following tables 13 and 14 to summarize the most relevant aspects of each element shown in figures 12 and 13. "Gold Standard PBL is meant an aspirational goal, a composite of the best researched-based and classroom-proven project design elements and instructional practices." Larmer et al. (2015, pp. 34)

Elements	Description
Student Leaning Goals	Students are the center of the learning goals. (pp.34)
Challenging problem or Question	Posing a problem or question gives students motivation not only memorize also use the content. "Questions focus students' attention on what is important to be learned and help students distinguish between relevant and irrelevant information" (Larmer et al., 2015, pp. 37).
Sustained inquiry	Opposing the educational conservatives discussed by Lamer et al. (2015, pp. 38) and Kirschner, Sweller, and Clark (2006), inquiry is not a waste of time for students and teachers. When done well, it allows engaging students in solving problems by searching and applying knowledge.

Authenticity	The inquiry needs to be sustained with authenticity. To do so, students need to be engaged in looking for solutions for problems, dilemmas, and worldview and trying to generate impact in the world. (Larmer, et.al., pp.40)
Students' voice and choice	Lamer et al. (2015, pp. 41) explained Dewey's stance on "the cognitive act": "Students' voice and choice are a prerequisite to critical thinking and problem solving. Students need some freedom to act and to their actions if they are to learn from the situation."
Reflection	"We do not learn from experience; we learn from reflecting on experience." Lamer et al. (2015, pp. 42) drew on Dewey (1938) to emphasize the importance that students and teachers reflect on the challenges and how to overcome them in each stage of the project activities.
Critique and Revision	Critique and revision should not be exclusive to teachers. Students should also be able to assess their own learning with their peers. Larmer et. al (2015, pp. 43)
Public Product	Students have the opportunity to share their projects beyond their peers and teacher and can display open exhibitions to the community. Larmer et. al (2015, pp.44)

Table 13. Description of essential project design elements (Lamer et al., 2015, pp.34)

The essential elements of this model, focus on student's learning goals, children educational motives are the most critical aspects of this design. Poising a problem or a question is key to develop a student-centered learning, the development of an inquiry mindset takes place during the development of the project, authenticity implies creativity as well, students` participation is active, they have voice and choice and during this process, they learn by reflecting from a critic perspective in what they learning and shares the result in a public way, through a presentation or doing a product.

Figure 13. Copyright ©2015 Buck Institute for Education. Gold standard: Project -based teaching practices (Lamer et al., 2015)

The following table describes the elements that teachers need to understand in order to acquire and improve their project based teaching practice.

Elements	Description
Project Design and Planning	Students start with an idea generated by the teacher or adapt an idea. (Lamer et al., 2015, p. 47).
Aligning the project to standards	"It means making sure the product students create will require the knowledge and skills laid out the standards" (Lamer et al., 2015, p. 48).
Culture building	Teachers build a culture of learning in an explorative and inquisitive way, in which students feel comfortable looking for answers and asking questions(Lamer et al., 2015, p. 48).
Managing project activities	Teachers have the role of project managers, making sure that goals, task, and dateline are accomplished on time and accurately. (Lamer et al., 2015, p. 49).
Scaffolding student learning	"Scaffolding may include everything from structured lessons and lecturers, to students handouts and readings, to tools and processes that support students in achieving goals" (Lamer et al., 2015, p. 48).
Assessing student learning	"In addition to assessing knowledge, teachers need to access conceptual understanding and success skills such as critical thinking/problem solving, collaboration and self-management" (Lamer et al., 2015, p. 51).
Engaging and coaching student performance	Teachers should try to engage and coach students to improve their performance. (Lamer et al., 2015, p. 51).

Table 14. Description of project-based teaching practices (Lamer et al., 2015, pp. 46)

This model developed by the Buck Institute is practical and also seeks to inspire teachers to promote a PBL culture in the classroom to prepare students for life after

school. “Learn deeply with understanding, and develop the success skills they will need in college, career, and life” (Lamer et.al., 2015 p. 53)

3.8 THEORIES FOR ANALYZING THE COLLECTED DATA

I used different theories to analyze the data collected during the different phases of the research. Figure 14 shows the theories and the chapters in which they are discussed.

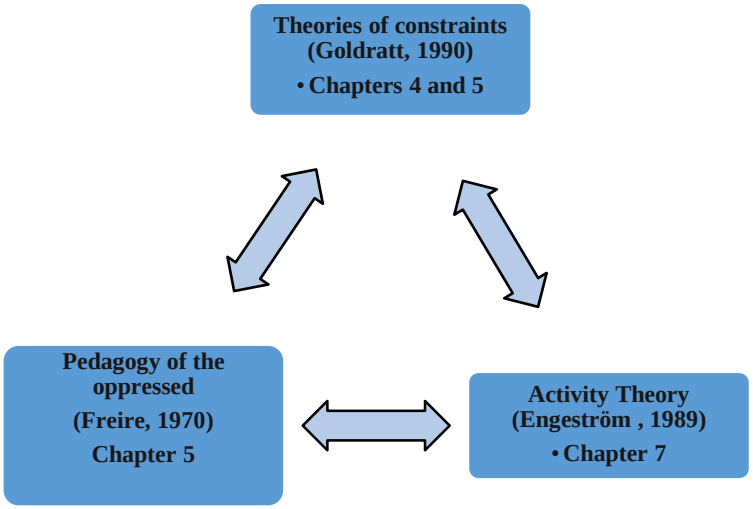

Figure 14. Theories of data analysis

3.8.1 THEORY OF CONSTRAINTS

The TOC is a “management philosophy, which emerged in the early 1980s. The development of TOC is credited in the main to Goldratt, an Israeli physicist who has had a remarkable impact on the business world, especially in the U.S.” (Mabin & Balderstone, 2000, pp.1). Although TOC was created for use by industry, Goldratt knew that TOC logic-based tools could also be adopted in the educational field. In 1995, he created the nonprofit TOC for Education, which has worked with more than 200,000 adult education stakeholders to have impacts on more than 8 million children in 21 countries (Suerken, 2010).

According to Goldratt (1990), a system constraint is “nothing more than what we all feel to be expressed by these words: anything that limits a system from achieving higher performance versus its goal.” TOC suggests five steps to identify the main constraints (Table 15).

Five steps of focusing the constraints	Key concepts
1. Identify the system' constraints	Identify constraints according to the impact on the goal.
2. How to exploit the system' Constraints	Everything the constraints will consume will be supplied by the non-constraints.
3. Subordinate everything else to the above decision	There must be a way to reduce their limiting impact, so the next step to concentrate on is quite evident.
4. Elevate the systems of constraints	If we elevate a constraint, we will finally break it (investing in additional resources).
5. Repeat the process (go back the first step)	This is a process of continuous improvement.

Table 15. Focusing steps (Goldratt, 1990)

I adopted TOC as a methodology for analysis because it offers thinking process tools to focus on the constraints I identified during the research process using different data collection methods, as presented in sections: 3.4.3, 3.4.4 and 3.4.6 and unfolded in chapters 4, 5 and 7.

Goldratt (1990) proposed three questions to ask to learn how to overcome a system of constraints. First, what to change? To answer this question, it is necessary to be sure what part of the process requires improving and to pinpoint the core problems. Second, to what to change to? It is important to reflect on possible solutions that can be easily implemented. Third, how to cause the change? Answering this question requires getting the participants involved in looking for solutions.

While Figure 15 is based on TOC, I furthermore used educational theory, Pedagogy of the Oppressed (Freire, 1970) to pinpoint the core problem. Accordingly, in the next section, (3.9.2 Freire's Educational Theory) I introduce Freire's (1970) views on education, and in Chapter 5, I explain in depth how I incorporated the into TOC. In Chapter 5, I also respond to the three questions in figure 15 using the tools suggested by Goldrat (1990).

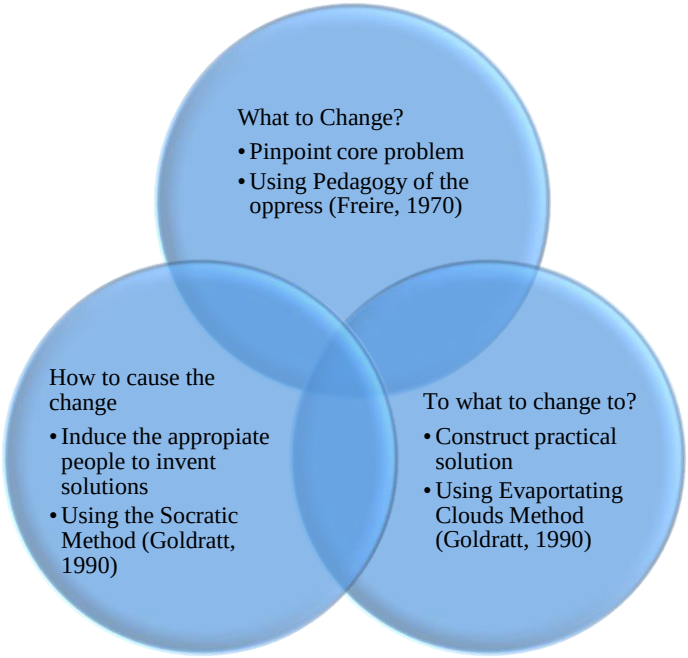

Figure 15. Improvement process focused on the systems of constraints (Goldratt, 1990) and incorporation of Freire's (1970) educational theory to pinpoint the core problem

3.8.2 FREIRE'S EDUCATIONAL THEORY

In designing this research, I found it relevant to study current pedagogical practices in the classroom to identify the main challenges teachers face in schools operating in unprivileged areas. I embraced the views of education expressed by Brazilian educator Pablo Freire's (1970) in his book *The Pedagogy of the Oppressed*. He applied method of problem-posing education with illiterate adults in his country, as well as in Africa and Central America. Freire believed that education is not neutral and should be used to liberate individuals. He promoted dialogue between teachers and students, horizontal communication and discussion about social issues: poverty, *favelas*, freedom, oppressors, oppression, and other related topics. His learning theory was opposed to the "banking" concept of education, which he criticized for putting students in passive roles, merely receiving, memorizing, and repeating.

Freire pointed out that school is not only a space to learn how to write and read but also to realize immediate change in individuals and society. Education should motivate students living in marginalized areas to transform their reality, should strengthen their self-esteem, and should teach them that they are not inferior to

anyone. “People come to see the world not as a static reality, but as a reality in process, in transformation” (Freire, 1970, p. 71).

Freire was a pioneering applying student-centered approaches to education in impoverished areas in Latin America. “Problem-posing in education,” a term coined by Freire (1970, p. 83) in *Pedagogy of the Oppressed*, emphasizes critical thinking for the purpose of liberation. Freire’s perspectives inspired me to believe that PBL and problem-posing share the same values and provide the same possibilities for students to become part of their own learning and transformation processes, which allow them to free themselves and succeed regardless of socio-economic background. Freire (1970, p. 59) declared that “education must begin with the solution of the teacher-student contradiction, by reconciling the poles of the contradiction so that both are simultaneously teachers and students.” Aligning with his view, I identified the main contradictions during the analysis and exploration phase in this research (Chapter 5).

3.8.3 ACTIVITY THEORY

Cultural-historical activity theory (CHAT) originated in Russian psychology during the 1920s and 1930s based on the work of Lev Vygotsky a Russian Jewish scholar who lived through the 1917 Soviet Revolution, and his students, Alexei Leont’ev and Sergei Rubinstein. AT provides a lens through which to study human activity and to understand “who is doing what, why, and how” (Hasan & Kazlauskas, 2014, p. 9).

According to Yamagata-Lynch (2010), Engeström (1987) further developed analytical methods within AT by introducing activity systems analysis, which is used to map the co-evolutionary interactions and effects of individuals or groups and their environment. AT extends mediated action as a model of human activity that accounts for sociopolitical situations (Cole, 1996). It addresses both the individual and the environment in order to move away from earlier person-focused CHAT methods.

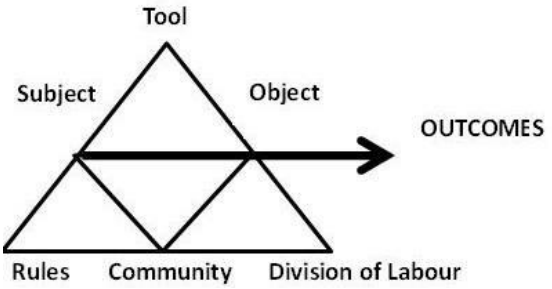

Figure 16. Engeström’s (1987) representation of a collective activity system

According to Hasan and Kazlauskas (2014), this activity system emphasizes the distinction between the object or the motive for an activity and its outcomes, which may be many and not always those anticipated or desired.

I analyzed the implementation phase using AT and studied how each part of the activity system was related to understanding the core contradictions inherent in shifting from a teacher-oriented pedagogy to a student-centered approach using XO computers as the main tool to produce changes in teaching practices. I explored the contradictions in subject–tools–object; subject–object–rules–division of labor; and community–tool–object. In Table 16, I present the importance of each activity system for the third- and fifth-grade classes, and in Chapter 7, I apply AT to analyze the implementation.

Elements of the activity system	Role of the elements in the activity system
Subject	The implementation phase involves the participation of students and teachers.
Tools	The means to perform the activity, XO computers, and other didactic materials play an important role.
Object	The prototype lessons are tested in two classes.
Rules	New rules govern performing the activity
Division of labor	The new responsibilities of teachers and students are defined.
Community	The main stakeholders involved are the school and the Zamora Terán Foundation.
Outcomes	The desire outcome is to enhance students' 21st-century skills.

Table 16. Importance of each activity system for third- and fifth-grade classes

I used AT to understand the activity system and how the participants in this research could contribute to improving teaching and learning practice. This theory allowed the practitioners and me to identify the needs and contradictions and develop along with them solutions.

3.9 ETHICAL CONSIDERATIONS

Participation in this research is voluntary, this study involves teachers working with children in the classroom testing the prototype design. Children identities are kept in anonymity to protect their privacy; however, the interviewed teachers agreed to use their real name in this research. The development of this research does not involve physical or emotional damage to the participants. All participants were informed about the objectives of this research and they freely consented to participate in this study.

3.10 POPULATION STUDY

Centro Básico Padre Claret was the school involved in this study. It operated in a suburban area among the most dangerous in San Pedro Sula (see Chapter 4 for details on the context). The participants were 25 elementary school teachers who used XO computers provided by ZTF in the classroom. During this research, all the teachers attended a workshop on PBL principles, and from among them, the school principal and the ZTF director chose two teachers who met the following criteria: they showed positive attitudes toward the development of training in this study. Although not a daily basis, the third- and fifth-grade Spanish teachers used XO computers to help students improve their reading and writing skills, one of the main weaknesses of the Honduran educational system, according to a report from Informe Progreso Educativo Honduras (2017) in English Honduran Educational Progress Report.

The children participating in the study belonged to the classes of the chosen teachers and consisted of 48 third graders and 40 fifth graders studying Spanish.

Figure 17. Teachers and children participating in the study

I had the opportunity to work with this school thanks to the support of ZTF, the school's main technology provider. I contacted the executive director, Leslie Ramos, by e-mail to explain the purpose of the research, and we held a Skype meeting to give more details about the project. The school principal and teachers agreed to participate because they shared the common goal to improve the quality of education through the use of technology and appropriate pedagogies in public schools. This research was aimed at influencing students' microsystem in the school (Bronfenbrenner, 1979) by training teachers and school administrators to change their pedagogical practices and actively incorporate ICT.

3.11 CONCLUSION

This research design begins with a first phase exploring the school's internal and external contexts and providing the teachers with an introductory workshop in PBL. The participants were 25 elementary school teachers who had XO computers available

in their classrooms. The researcher's role in that phase was as the workshop facilitator. The first phase provided the input for the second phase designing a lesson prototype for use in the classroom. In the third and final phase of the research, the lesson prototype developed in the second phase was implemented, and its implementation was analyzed. ZTF, the school's main provider of XO computers and technical support, supported this research by identifying the school and providing the necessary logistics to conduct the empirical work. Figure 18 shows the chapters in which I address the research questions introduced in Chapter 1.

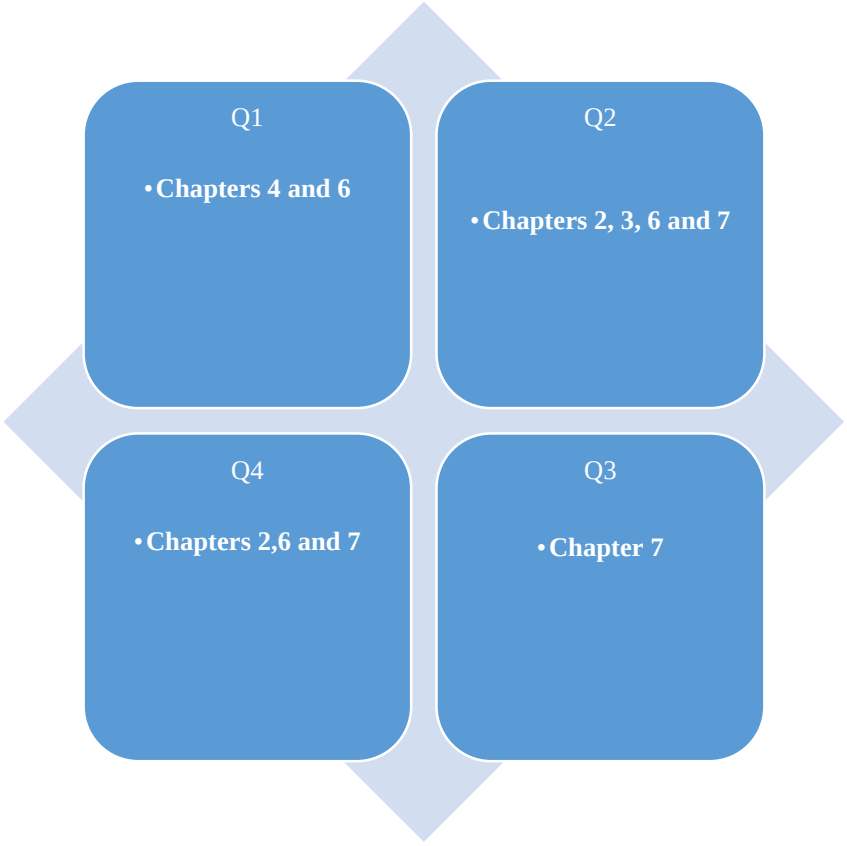

Figure 18. Research questions guiding the study

CHAPTER 4. UNFOLDING THE ANALYSIS AND EXPLORATION PHASE

In this study, the unit of analysis is a school in an unprivileged area with a high crime rate and controlled by various criminal gangs. For the students and teachers, a commute under risky conditions was their daily routine. However, for me as a researcher, this situation presented a new experience, so I needed to understand how things worked in the external context, at least in the area close to the school—the common matters the teachers and students faced every day going to school and returning home. In addition, I explored the internal school context, teacher–student interactions in their natural setting, school infrastructure, and use of technology in the classroom. I interacted with the teachers and students to listen their voices. I used different methods to collect data: visual anthropology, participant observation, surveys, interviews, and future workshops. I analyzed the data using the TOC in order to identify the main constraints to overcome to introduce PBL using ICT in a public school operating in an impoverished area.

4.1 STARTING THE EXPLORATION PHASE BY DESCRIBING THE EXTERNAL CONTEXT

In this section, I unfold the analysis and exploration phase exploring the external context of the school. I used the visual anthropology approach to describe and analyze how the external context where the school operated influenced the children's education. Part of the scope of the research was to understand the constraints to implementing PBL using computers in schools in marginalized areas with high crime and poverty rates. I supported my findings in this part of my research with photos, interviews, and surveys, although the pictures could not replace my role as an observer (Figure 19; Collier & Collier, 1996). I used the visual anthropology approach to describe and analyze how the external context where the school operated influenced the children's education.

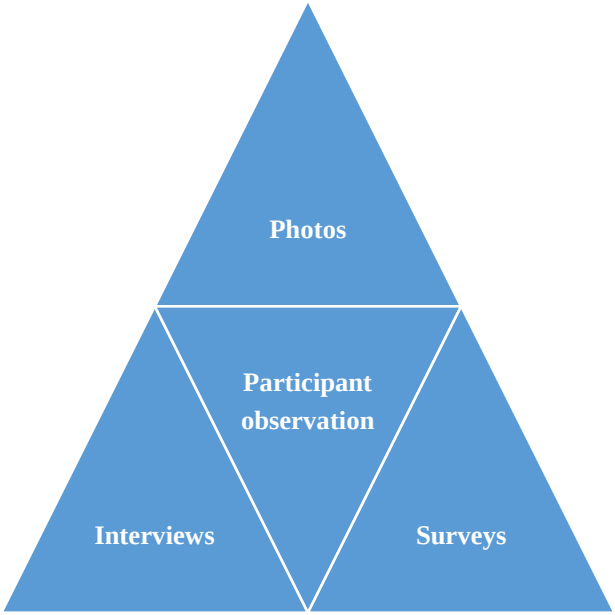

Figure 19. Data collection methods during the external and internal exploration of the context

4.1.1 LOCATION OF THE SCHOOL

Centro Básico Padre Claret was a suburban area of San Pedro Sula, considered to be the second-most dangerous city in the world, according to the World Atlas (2018). In 2016, it had 111.03 murders per 100,000 residents. Moreover, this school was in one of the city's most dangerous sectors, Rivera Hernández, an area of 55 low-income neighborhoods with high levels of violence and criminality controlled by six gangs, according to Insight Crime (2016). The school was in Asentamientos Humanos (Human Settlements), which had dirty roads and was vulnerable to flooding.

This area had private Internet and mobile phone service and poor coverage of state telephone services. People used three main modes public transportation: collective taxis, micro buses, and large buses. Coverage of public and private transportation was limited at night due to the high rates of violence and criminality. While I was visiting this area, I followed safety advice from locals, stayed inside the school most of the time, and took the pictures from the main door of the school and from inside the car. However, teachers and students who lived and worked in this area passed through these dangerous neighborhoods every day. As an outsider, I traveled to the school in ZTF's vehicle, heeding warnings not to drive my own car to reduce the risk. The pictures and images give a view of the area that makes it easier to understand the situational context. I took these pictures with my mobile phone from the main door of

the school, following the advices of the school's sole security guard and other school staff.

Figures 20 shows part of the school wall built with concrete and topped with barbed wire in an attempt try to protect the children and school staff from the dangers of the outside world, surrounded by violence and muddy streets. The principal raised the funds to build the wall. In contrast, a big sign on the wall proclaimed the name of Jesus Christ. In this sector, there were many churches working with communities to bring hope to many families living there.

Figure 20. . School wall and the main unpaved street in front of the school

4.1.2 APPEARANCE OF THE NEIGHBORHOOD

Figure 21 shows the unpaved street in front of the school, along with some houses built of concrete. There were only a few trees given the city's high temperatures reaching 30–40 degrees Celsius. This picture was taken around 10 a.m., and there were no people circulating then. According to locals, people only went out if they needed to because this area was considered to be very dangerous. At the end of this block started another zone controlled by a different gang.

Figure 21. View from the school's main entrance of an unpaved, empty street, nearby concrete houses, a few trees, and electricity power lines

The Google Map image in Figure 22 and 23 gives accurate information, and I verified the location with the teachers participating in this study. The school was in Asentamientos Humanos, but children from other nearby neighborhoods were enrolled as well.

Figure 22. Neighborhood attending Padre Claret School

Figure 23. Padre Claret School, near a local police station and two churches of different denominations, along with seven more churches, a drugstore, and a communal health center in the sector

4.1.3 THE PEOPLE AND DAILY CYCLE AROUND THE SCHOOL

Figure 24 presents a picture I took from inside a vehicle around midday at the end of the morning session of classes. It shows parents and relatives waiting in small groups outside the school's main door to pick up and walk their children home. A snack and fruit vendor also waits to sell her products to the children. This picture also shows that this area relies on an electric system provided by the state company, as well as a mobile phone tower belonging to a private company and a water tank belonging to a household.

Only a few parents picked up their children after school. Most children walked by themselves, while a few took a bus to get home. This was a dangerous area, so the children were not allowed to take computers home, as they did in other countries where ZTF works. The foundation and the school did not want to risk the children's security, so the computers were disconnected immediately to protect them in case they were lost or stolen.

Figure 24. Presents a view at the end of the school wall, around 200 meters from the school's main entrance. This picture was taken at the same time as Figure 23. Only one person walks in middle of the dirty road, and a motorcycle goes in the opposite direction

Figure 25. Nearly empty area opposite the main entrance of the school

The picture in Figure 26 was taken by Katie Orlinsky for *The New York Times* (2016) and used to illustrate the opinion article "How the Most Dangerous Place on Earth Got Safer." This photo presents graffiti by the gang controlling this particular area.

Figure 26. Name of the gang controlling the area (New York Times, 2016)

4.1.4 CHALLENGING SCHOOL ENVIRONMENT

The external context in which the school operated was challenging for the students, teachers, parents, and non-profit organizations. I validated the data collected through photography by interviewing the school principal, José López. I asked him how the socio-economic environment affected the learning process in the school. López believed that "school drop-outs have their roots in the external context. The main problems are gangs and immigration. Due to the violence, some families have to leave the neighborhood because they feel that their life are at risk." López supported his comments using school data showing that in 2014, the school issued 120 school transfers for families moving to different neighborhoods, cities, or countries. That year, there were 45 school dropouts who did not enroll in other schools. López assumed that they immigrated to the United States or other areas. López explained that parents commonly went to the United States illegally and asked their children to join them later. Living, working, and studying in this kind of environment with crime and violence could affect the children's microsystems. Every day, they faced physical and emotional threats, negatively affecting the quality of potential learning opportunities in the community and school (Bowen & Bowen, 1999).

4.2 EXPLORING THE INTERNAL CONTEXT

In the exploration phase, I participated as an observer, using a semi-structured guide to conduct my classroom visits. I conducted an in-depth interview with Daylin Alcerro (Figure 27), a fourth-grade teacher who had 38 students and worked 12:30–5:30 p.m. Monday through Friday and 7 a.m.–12 p.m. on Saturday two times a month. She was one of the founders of the school and had worked there since 1989. She taught all the subjects: Spanish, math, social science, physical education, and arts. The school year lasted from February to December.

According to Alcerro's experience in the current educational system, the teachers bore all the responsibilities (Figure 27). She stated, "Sometimes I feel that everything falls on my shoulders, and education depends only on teachers' lectures. Currently, we have XO computers, but the family should also get involved in the process." She believed that the use of XO computers motivated students to attend classes because most did not have computers at home: "I feel that XO have come to help."

Figure 27. Teachers delivering the computers before starting the class and teacher explaining the lesson using a teacher-centered approach

4.2.1 OBSERVING CLASSES

I observed a fourth-grade class of 39 students, which was a large group for a single teacher (Figure 28), and a third grade class with 35 students (Figure 28). The teachers had to speak loudly while giving instructions on how to complete an assignment using XO computers to search for the answer. Some students seemed to lose concentration very easily and start talking to each other.

Figure 28. Teacher walking in the middle of the classroom trying to reach each student and teacher standing in front of the classroom trying to manage a large class

I interviewed Melvin Joel Castro Figueroa, a fifth-grader teacher who had worked in the school for more than 11 years. He pointed out that the school lacked economic resources to improve the classroom infrastructure and that using XO computers required appropriate technical support (Figure 29). He had taught large groups, up to 50 students in some cases. According to Figueroa, "XO computers are used as a pedagogical resource, but we lack Internet access, and the activities on the XO are specific. We have these limitations."

Figure 29. Figure Children sitting in damaged chairs for several hours / Time-consuming connecting and charging XO computers in classes

I interviewed López, the principal, to support the teachers' comments and my own observations. He acknowledged, "The classrooms are not adequate. There are many students in the classroom. The furniture is not appropriate. There are at least 45 students per classroom." According to Lopez, even though ZTF provided XO computers for each student in the class, technological, infrastructural, and pedagogical limitations remained. He believed that in these circumstances, it was very difficult to use a tutorial method: "To do that, we need to have smaller groups, so we can deliver

a personalize education. It is very difficult for the teachers to review all the homework. It is time consuming. Sometimes it takes up two hours from the class to review their assignments."

From the science class I attended as observer, I elaborated a process chart to describe how the science lesson was taught to third graders in elementary school (Figure 30). To do so, I sat at a school desk for one hour to observe how the teacher conducted the class. My aim was to understand the pedagogical approach and how XO computers were used in the classroom.

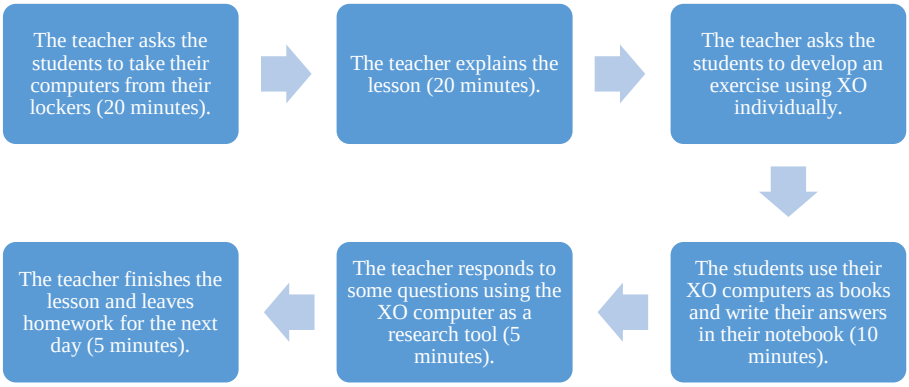

Figure 30. . Process of a traditional science lesson delivered to third graders

4.2.2 GENERAL DESCRIPTION OF THE CHILDREN PARTICIPATING IN THE PROJECT

I conducted a survey of third- and fourth-grade students to understand the socio-economic context of the children attending the school. I recruited a sample of 21 children, with an age range of 8–12 years old. I found that all the children interviewed lived in the underprivileged Rivera Hernández Sector, and had low-income parents who worked informal jobs, such as kitchen helpers, tailors, street vendors, electricians, janitors, handicrafts, unskilled labor, cleaning, and truck drivers.

The children were all raised by their families. Eleven lived with nuclear families (parents and siblings), while the rest lived with extended families (grandmother, aunts, cousins). The economic support to attend school mostly came from their fathers when they lived together. When they lived with their mothers, single mothers were the only economic support. The children lacked Internet access at home. Only one had Internet access through her mother's mobile phone, and one had a computer at home for play, not homework. While administering the survey, I had the opportunity to have small conversations with the children and found that most did not receive any kind of family support to complete their assignments. They did not have learning resources to

consult, and there was not a library in the school or the community. Simple tasks, such as bringing a magazine or newspaper to use in class, were complicated and difficult to accomplish.

4.2.3 FACING DISRUPTION IN THE CLASSROOM ENVIRONMENT

The teachers' working hours were exhausted as they taught large groups of students without assistants. The furniture and equipment were deteriorating, and the classrooms did not have adequate ventilation for high temperatures. In the midst of this chaos, the teachers faced the challenge of using technology, XO computers, which were an excellent didactic resource but used with the pedagogy of the last century that made teachers the center of education.

Using XO computers was a challenge, and the teachers and students had to face issues such as lacking power chargers for all the computers. The teachers spent more than 40 minutes delivering and storing XO computers, forcing a pause in the teaching–learning dynamics. The students were not yet the center of education, and the greatest responsibility fell on the teacher, who still did not have the training to solve this situation. The teachers had not managed to incorporate the technology into the design lesson and made great efforts to reach all the children, who were easily disturbed and distracted given these conditions.

4.3 FUTURE WORKSHOP: A METHOD TO EXPLORE THE OPPORTUNITIES AND CHALLENGES TO INTRODUCING PROBLEM/PROJECT-BASED LEARNING AND XO COMPUTERS

In the previous section, I set the context of this study and provided an overview of the situation the teachers and students faced on a daily basis. In this section, the goal is to describe how the practitioners worked together, reflecting and identifying the aspects that limited the use of new technology and an active pedagogy to help enhance the students' cognitive development in this particular school environment. I conducted a future workshop to stimulate an open discussion among the practitioners to propose an ideal world, critically review their current situation, and finally propose desired changes.

A future workshop is a participative approach, promoting critical thinking, teamwork, and democratic principles and empowering the participants (Vidal, 2005). A future workshop is appropriate for developing countries where democracy is weak, and freedom of speech is risky, so the participants might be afraid to speak about their views. Future workshops were created with the intent to democratize participation and seek joint solutions to problems (Jungk & Müllert, 1987). In this case, the participants consisted of 25 elementary school teachers who had XO computers available for teaching in the classroom. I performed the role of the workshop facilitator, guiding

the participants through its different phases and working with staff with ZTF, the school's main provider of XO computers and technical support. I followed the steps proposed in future workshop method (Figure 31).

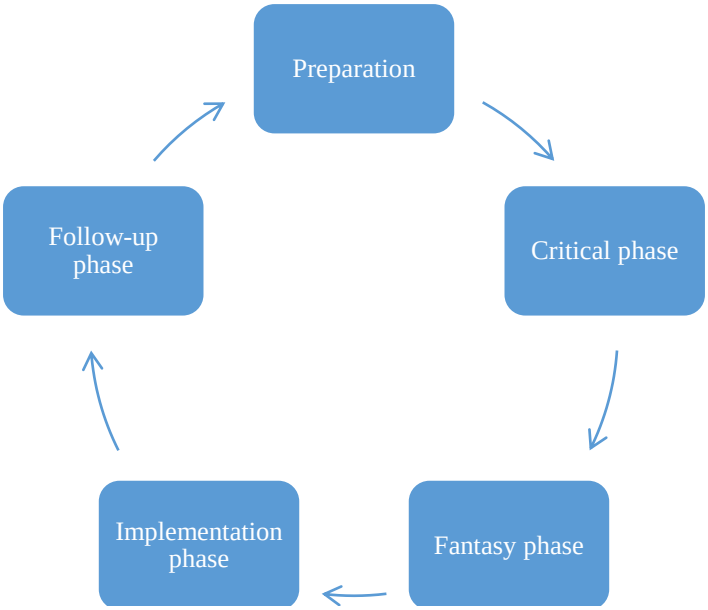

Figure 31. Future workshop phases (Jungk & Müllert, 1987)

4.3.1 PREPARATION PHASE

In this first phase of the future workshop, the participants and I determined the opportunities and constraints to introducing PBL as a pedagogical model by using computers in suburban schools to engage students in the process of learning by doing. This step was organized as a one-day activity. The researcher asked ZTF to book a room at the school equipped with a data projector, air conditioning, desks and chairs for group work, and sufficient space for the group to give presentations. The point was to have appropriate facilities to keep the participants focused during the workshop.

The future workshop followed all the essential phases of this method, giving an hour to each phase. The researcher organized teachers according to their class schedule into morning and afternoon sessions. In each session, the researcher divided the participants into three groups and explained the method, objectives, and duration of the workshop. All the group members discussed the same questions and wrote their key points on the large pieces of paper. Each group designated a volunteer to take notes and two persons to make a presentation on their behalf.

Figure 32. Teachers gathering in groups

4.3.2 CRITIQUE PHASE

According to Valqui Vidal (2005), brainstorming is the preferred creative technique, followed by structuring and grouping of ideas into main sub-themes. This process is called the diverged phase, and the participants may generate many ideas and seek solutions (Purushothamn, 2013; Vidal, 2005, 2006). In each group for this study, the clerk wrote down the main points of their discussions on large pieces of paper, and the designated person made the presentation to the other groups (figure 32).

I presented the driving questions for the participants to discuss during all the phases of the workshop:

1) What are the main constraints you face when using XO computers in the classroom?

2) What constraints do you face when you use a teacher-oriented pedagogy and XO computers?

During the morning and afternoon sessions, each group discussed and brainstormed what they considered to be the main limitations they faced when using XO computers and teacher-oriented pedagogy

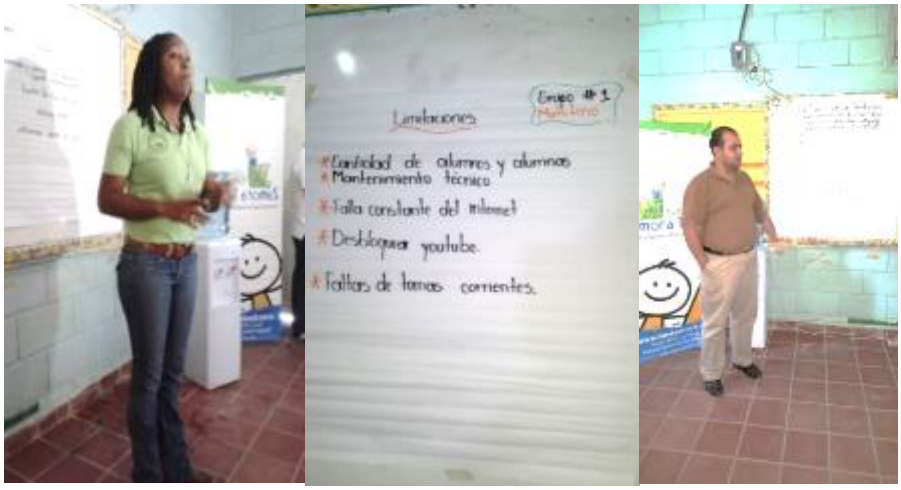

Figure 33. Teacher in the morning session / Limitations identified by a group of participants / Teacher in the afternoon session

In my role as a facilitator, I asked the participants in both sessions to place all the large papers on the wall and use the sticky notes to classify the most critical points. I collected this information produced by the teachers, and in my role as a researcher, I, along with the practitioners, elaborated a table grouping the critiques identified by the participants (Table 17).

Information and communication technology		**Pedagogy**	**Infrastructure**
Computers	**Internet**		
Poor technical maintenance of XO computers	YouTube blocked	Large groups of students	Small classrooms for large groups
Few electrical outlets to recharge XO computers	Poor Internet connection	Lack of control of computer activities	Furniture in poor condition
No protection to prevent deletion of XO programs without authorization	Limited Internet access in classrooms	Poor student performance Literacy problems Analytical problems	Poorly ventilated classrooms
No protection to prevent downloading unauthorized	Improper websites for children not blocked	Student absenteeism	Poor lighting in classrooms

games on XO computers			
Frequent failure by XO users to properly shut down the computers		School dropout	No library available for research
		No use of XO computers to promote active learning	

Table 17. Key aspects identified by participants during group discussions and presentations

Table 17 presents the convergent process that required the participants to choose the best options on which to work based on the two driving questions about pedagogical and technological constraints.

4.3.3 FANTASY PHASE

In the fantasy phase, the participants used drawings to creatively express their dreams and aspirations and wrote descriptions on pieces of large paper to express in words aspects they could not represent in drawings. In groups, they discussed the inputs collected and recorded a bank of ideas. This phase was highly creative and required creating a relaxed atmosphere to motivate the participants to freely engage in discussion. In the previous phase, the participants used the driving questions as the guidelines for discuss the current situation, but in the fantasy phase, they focused on creating an ideal world without limitations or resource constraints of any kind. In this phase, the practitioners became dreamers and visionaries as part of the divergent process (Vidal, 2005, 2006).

The fantasy phase in this workshop followed this process. The teachers discussed the ideal world and contrasted it to their view of the real-world situation presented in the critique phase. All the group members expressed their views, and one person was chosen to draw the group's ideas on a large white sheet, while another person was designated to present the group's drawing. The participants agreed that what they considered to be a fantasy might be a reality in other places. As Vidal (2005, pp. 7) pointed out, "it happens that ideas that are unrealistic today might be implementable in one or two years' time due to radical changes in the economic, social and political environment."

4.3.4 MORNING SESSION

Figure 34. Teacher representing group no. 1

During the morning session, the groups represented their fantasies with drawings. Group 1 stated that it tried to illustrate the ideal classroom with nice furniture and enough room for the teacher to move around and help each student. The group dreamed of having smaller classes with a maximum of 35 students, assistants for first-grade classes, and air-conditioned classrooms due to high temperatures of up to 40 degrees Celsius most of the year. Regarding technology use in the classroom, the group's drawing portrayed wireless chargers and free use of YouTube for teaching. Additionally, the presenter highlighted the importance of hiring a psychologist to give advice to students and teachers.

Figure 35. Teacher representing group no. 2

The presenter for Group 2 showed its drawing expressing a desire for tutorial-style teaching. In the drawing, an instructor taught a small class of 25 students face to face using an interactive whiteboard in a classroom equipped with air conditioning and comfortable desks. During the presentation, the participant talked about the group's dream to hire an assistant for first grade and for a cafeteria to serve balanced meals. The group also shared the dream to receive online workshops for teacher training.

The presenter for Group 3 introduced the drawing of a smiling school. A sun representing a nonprofit organization illuminates the school roof, comprised of the government, family, and teachers and covering the children. On a large piece of paper, the group wrote other things they fantasized but could not show in the drawing:

using computers as pedagogical tools for teaching as part of the national educational curriculum and having textbooks and teaching materials for each class, appropriate restroom facilities, running water, interactive whiteboards, and healthy cafeteria food. They talked about the possibility of allowing students to take computers home, providing scholarships for children in need, building a school cafeteria, serving healthy meals to the children, and hiring a psychologist. This group fantasized about teacher training in all the subjects (e.g., languages, sports, music, and a library).

Figure 36. Drawing by group no. 3

4.3.5 AFTERNOON SESSION

During the afternoon session, the teams presented their drawings. Group 1 focused on technological aspects and pointed out the importance of having electrical outlets for each row of desks and two data projectors in the school or one for each classroom. The group wished that each student could bring an XO computer home. They also desired an assistant teacher for first grade paid by ZTF.

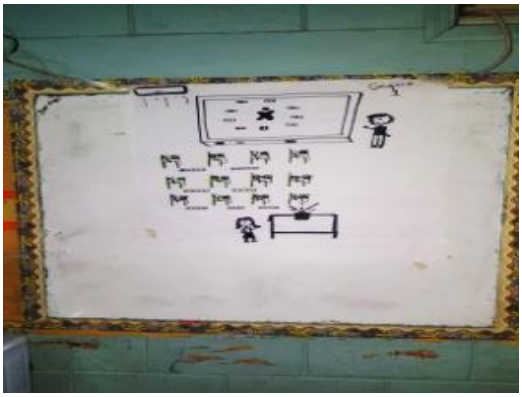

Figure 37. Drawing presented by group no. 1

In the drawing, Group 2 used a lot of color to portray a school serving fewer than 30 students in classrooms equipped with a data projector and air conditioning and with teachers' assistants in all grades.

Figure 38. Drawing presented by group no. 2 / Drawing presented by group no. 3

Group No. 3's drawing represents a fifth grade classroom. All the students easily use XO computers, which each have battery chargers. Internet access is available, and all the computers are connected to the Internet at the same time. The group also dreamed about having fewer students per class, along with data displays. They wished that the children could bring home their XO computers to work on their daily assignments.

4.3.6 FURTHER THOUGHTS

As the facilitator of the future workshop, I found the fantasy phase to be very inspiring. However, at the beginning of the phase, I felt some concern about how the participants could take part because I could not help them solve issues unrelated to the research questions, and I did not want to generate false expectations for the school or the teachers participating in this study. However, during the process, I felt relieved to see the participants working freely and full of optimism for the next phase when they will choose areas where they could and could not begin work immediately.

4.3.7 IMPLEMENTATION PHASE

In this stage, the participants in both sessions decided which solutions they could implement. Even when the driving questions focused on computer use and pedagogical skills, they brought up aspects concerning children's welfare, broadening the scope. In this phase, ideas should be adapted to reality, and the participants should discuss and perform a critical evaluation from economic, technical, social, and political perspectives (Vidal, 2005; 2006). The participants followed the process described in Figure 39 to choose the most implementable ideas, keeping in mind the scope of the driving questions.

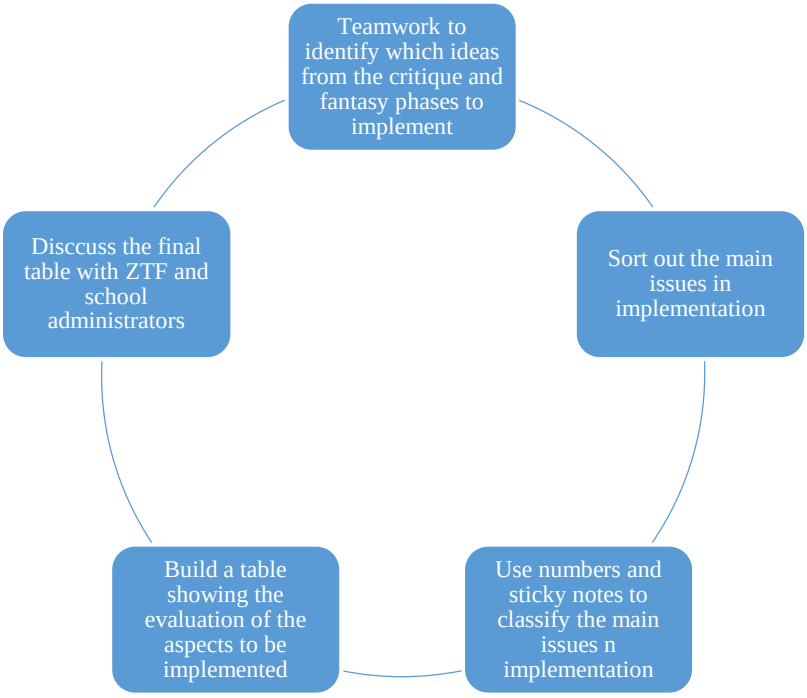

Figure 39. Steps followed to determine which solutions to implement

4.3.8 LIMITATIONS

During the future workshop, the power went off from 9:30 a.m. until 5 p.m., and as the temperature rose to 40 degrees, the teachers had difficulty focusing during the last part of the workshop. For this reason, the implementation phase was completed the next day. ZTF decided to use the conference room at Lafise Bank, the same organization that sponsored the foundation. This room was well equipped with air conditioning, comfortable chairs, and data displays. Breakfast was also provided to the participants.

4.3.9 IMPLEMENTABLE IDEAS

The participants identified issues from the previous phases and held another brainstorming session to decide which ideas they could implement based on their own experience. The driving questions helped the participants focus the discussion on the use of XO computers, pedagogy, and other factors affecting the teaching process. The participants gathered in groups and discussed which ideas from the previous phases they realistically could most likely implement (Figure 40). All the participants shared their results with other participants and engaged in an unstructured discussed of which aspects they found to be relevant.

Figure 40. Groups gathering to discuss the ideas to implement

Divided into groups, the participants from the morning and afternoon sessions placed the large papers on the whiteboard and used sticky notes to individually rate the importance of implementing the ideas (Figure 41) on a scale from 1 (very important) to 5 (not important; see Table 18).

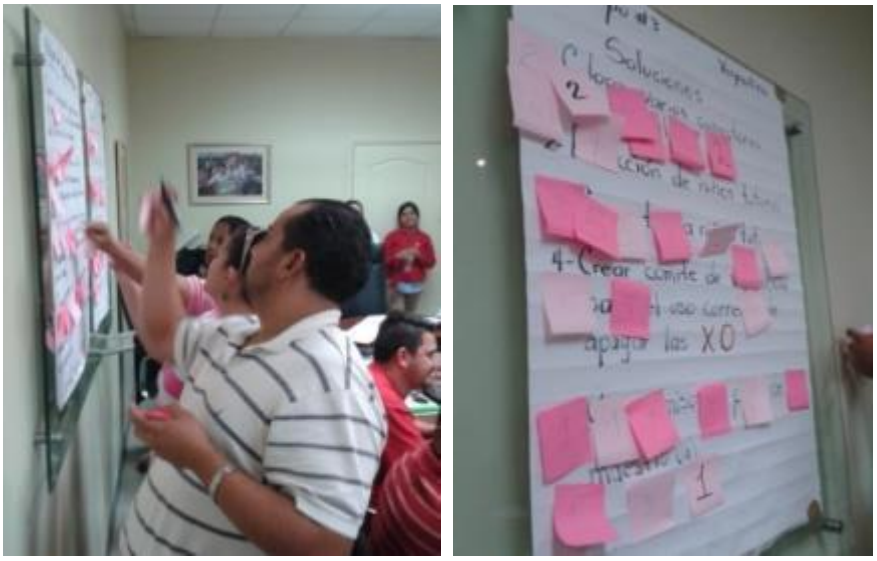

Figure 41. Participants rating the ideas on a scale of 1–5 using sticky notes

The participants developed tables 18 and 19. In one column, they wrote all the possible solutions to implement from the discussion and rated them on a scale from 1 to 5, as shown in Table 18.

Very Important	Fairly Important	Important	Slightly important	No important
1	2	3	4	5

Table 18. Scale for evaluating ideas

Aspects to implement	Very Important	Fairly Important	Important	Slightly important	No important
Scale from 1 to 5	1	2	3	4	5
Adequate school furniture					
Air-conditioning in the classrooms		6	5	1	
Data show					
First aid kit			7		2
Hire a psychologist		2	1	1	1
Improve children diet in school		1	7	1	3
Improve Internet connection	4	3			2
Not exceed he number of students per classroom		2		1	1
Parents involvement				1	
Repair current electric outlets	11	3			
Train children tutors				1	
Train teachers on ICT	8	2		2	
Unblock YouTube	4				
Wireless computer chargers		2		4	_

Table 19. Morning session assessment of aspects to implement

The participants in the morning session rated three ideas as very important to implement, six as fairly important, seven as important, seven as slightly important, and five as not important. To focus on the main aspects identified by the teachers, I chose to reflect on the first three evaluation categories presented in Table 18: very important, fairly important, and important. The participants considered making technological improvements to be very important. Buying and repair electric outlets to charge XO computers was a priority because the teachers wasted too much time setting up the computers. Some teachers believed that doing so was time consuming and wasted class time, so they preferred not to use them. The teachers wanted to be trained in ICT use and the most appropriate pedagogies to integrate in their classes. The Internet connection was very slow and sometimes did not work, which made it difficult to use Google to research assignments. When YouTube was blocked, the teachers could not use it a didactic resource.

The participants rated as fairly important improving the classroom environment. They considered it to be necessary to install air conditioning or fans to improve the ventilation due to the high temperature of this sector, which did not have many trees. They also viewed as important improving factors related to health and nutrition. They requested a first aid kit to attend to emergencies at school and desired to improve the quality of food served in the informal school cafeteria, also known as a *glorieta* in Honduran.

Aspects to implement	**Very Important**	**Fairly Important**	**Important**	**Slightly important**	**No important**
Scale from 1 to 5	1	2	3	4	5
Create a committee to assure the computer maintenance in the classroom				3	2
Hire a computer technician to provide support				4	3
Improve Internet connection	10	2			
Include the use of XO in the classroom program		2		2	
Install more outlets in the classroom					
Open a new public school in the sector			3	9	
Program XO to prevent students to delete applications accidentally		2	3	2	1
Raise awareness among parents to send children to school			3		

Raise money to buy new electrical outlets to charge the XO	8	3			
Schedule a program to use Internet			3	5	2
To schedule a program to recharge XO			3	1	4
Train children to assist teacher with computers				2	3
Train teachers on ICT	11	2	3		
Unblocked YouTube and get filters to restrict inappropriate pages			3	2	

Table 20. Afternoon session assessment of aspects to implement

The participants in the afternoon session rated three ideas as very important to implement, five as fairly important, nine as slightly important, and seven as not important. As in Table 19, I chose to reflect on the first three evaluation categories in Table 20. The participants considered it to be very important to improve Internet access for classroom use as a didactic resource; to provide teachers with more training in ICT use; and to raise money to buy new electrical outlets to charge XO computers to avoid wasting time and resources in the classroom. The participants considered it to be important to include the use of XO computers in the classroom and to program XO computers to prevent students from accidentally deleting applications. They considered it to be important to open a new public school in the sector, to program XO computers to prevent students from accidentally deleting applications, and to raise awareness among parents about the importance of sending children to school. Schedule programs to use the Internet and recharge XO computers, train teachers in ICT, unblock YouTube, and get filters to restrict inappropriate page.

In conclusion, tables 19 and 20 highlight the most relevant aspects to improve, which were related to technology, infrastructure, pedagogy, and children's nutrition and safety. In both sessions, the participants agreed on three main ideas: training teachers to scaffold their pedagogical and technological skills, improving Internet access, and repairing electrical outlets. The participants thus found it relevant to work collaboratively to optimize use of the school's resources.

4.4 ANALYSIS OF DATA FROM THE EXPLORATION PHASE

I carried out a general review of all the data collected, including my observations, in-depth interviews, photographs, written notes, and drawings from the future workshop (Cresswell, 1998). I analyzed the data using the TOC and identified two kinds of constraints: physical (i.e., people, ICT, and school infrastructure) and non-physical (i.e., shifting the teachers' paradigm from a traditional pedagogy to active learning).

In this study, some constraints were internal; others were external. To determine their differences, a constraint that could be fixed from inside the system was internal; otherwise, a constraint was considered to be external because it could be handled from the inside (Dettmer, 1998; Goldratt, 1990).

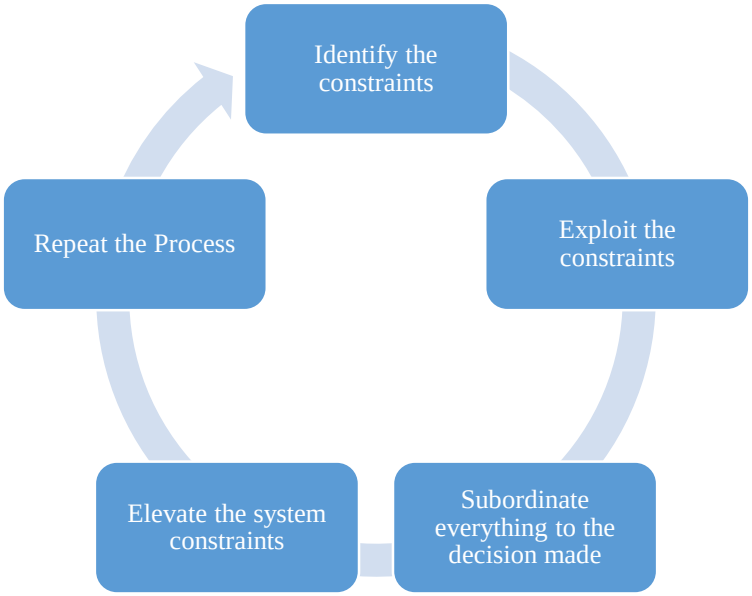

Figure 42. Framework for analyzing the current situation

TOC views constraints as chained together, not existing separately. For a company, education is a means, not a goal, but for an educational institution, it is a goal itself. I used TOC to analyze the constraints to overcome to introduce a different way of teaching to improve children's learning experiences by using XO computers.

Questions	Step 1	Step 2	Step 3	Step 4
What are the main constraints the teacher faces when use the XO computer in the classroom?	Identify internal (I) and external (E) constraints	Exploit the constraints (make changes using the same resources)	Subordinate and synchronize the constraints (reduce their limiting impact)	Elevate the performance of the constraints (eliminate the constraints)
Physical Technological	Weak Internet connection (l and E)	Have periodic and ongoing reviews of Internet services Enable YouTube, and use filters to block pages that have material unsuitable for children	Improve the communication system among ZTF, CEB Padre Claret, and the Internet provider	Have a permanent committee including both internal and external volunteer teachers and students from the CEB and local universities to provide systematic technological support

	Poor equipment maintenance (I and E)	Repair the connectors to charge the computers	Standardize the connectors system to charge the computers in the school	Appoint a permanent technician to maintain the equipment
	Secure hardware and software (E)	Configure XO computers so that students cannot delete applications by accident	Hold a bimonthly planning meeting to review to review the XO hardware and software	Have a permanent committee including both internal and external volunteer teachers and students from the CEB and local universities to provide systematic technological support
	Lack of appropriate infrastructure and equipment (I)	Repair the furniture and use XO computers as didactic tools	Enhance the use of existing educational technologies in the classroom	Raise additional funds from international donors Acquire new equipment to improve the classroom: air conditioning, data displays, appropriate furniture for children, smart blackboard
What kind of constraints do teachers face when using computers and a teacher-centered teaching approach?				
Non-physical Pedagogical	Little teacher training (I)	Systematically train teacher in how to use ICT in teaching. Equip teachers with new pedagogical skills to place students at the center of the learning process	Systematically restore the pedagogical circles program	Establish a permanent committee to systematically program pedagogical training based on a student-centered approach.
	Lack of teaching support (I)	Strengthen the mentorship program so that the best students become mentors facilitating technology and class subjects Involve parents in school activities to reduce truancy	Empower children to become mentors (peer to peer)	Implement a program to promote mentorship Organize a committee with volunteers from local and international universities with education programs that can contribute to achieving the goal
Other topics related to improving education that arise during: Non-physical Children well-being	Nutrition (I)	Train the food staff (glorieta) staff to serve healthy food.	Create and promote an internal campaign to stimulate healthy food consumption in the school community	Seek alliances with local universities offering degrees in nutrition

	Community projection (I)	Train teacher and students from nearby schools in ICT	School and ZTF work together to make the community safer	With the support of ’nongovernmental organizations and local authorities, develop community programs to increase student achievement negatively impacted by various factors (e.g., domestic violence, migration, poor nutrition, family disintegration, and child labor)

Table 21. Internal and external constraints based on the theory of constraints (Goldratt, 1990)

In the next section, I explain each step presented in Table 21 and study the effects of each identified constraint on achieving the goal.

4.5 UNDERSTANDING THE INTERNAL AND EXTERNAL CONSTRAINTS

With the data gathered, I identified the internal and external constraints the teachers faced when using XO computers in the classroom.

4.5.1 TECHNOLOGICAL CONSTRAINTS

In the first step, I identified the systems of constraints keeping in mind the school’s goal to provide access to quality education. Its Internet connection provided for free by a private company was weak, and it took too much time to search for information or to download a video. Equipment maintenance depended on volunteers who could not provide support on a daily basis. The school did not have the resources to provide maintenance for XO computers, and when one was not working properly, they had to wait for an external technician to visit. The hardware and software were unprotected, and the classroom lacked appropriate furniture. Due to the lack of enough connectors to power XO computers, the teachers spent a lot of time charging computers before starting the class.

The second step was to exploit the constraints, using current resources to maximize opportunities. The school administrators and ZTF should meet the current Internet providers to explain their problems and find solutions. ZTF could enable XO computers with YouTube access to enrich the class content and could install filters to prevent wrongdoing and protect computers from students and teachers accidentally deleting applications. Bearing in mind that this situation could not change during my research, however, it was possible to exploit these constraints by using the current

infrastructure and equipment. For example, the students could be redistributed to work in groups, and XO computers could be used as a pedagogical tool related to the core of the course lesson rather than appendices to the class or a reward, such as playing with the XO games.

The third step was to subordinate and synchronize the constraints. This goal likely could be achieved by using the current resources to maximize the opportunities, for instance, by improving the communication process with ZTF and CEB Padre Claret and ensuring that all the classrooms had appropriate connection systems to recharge XO computers. The fourth step was to elevate the performance constraint and eliminate it as a constraint. It could be feasible to organize a multi-stakeholder committee to work systematically to fix each constraint. However, external resources would be needed to eliminate all the constraints, so doing was not possible during this study due to time and resources limitations.

4.5.2 PEDAGOGICAL CONSTRAINTS

I analyzed the data collected on the main limitations the teachers faced when using XO computers and a teacher-centered pedagogy. The systems of constraints focused on the teachers' very limited pedagogical training and persistent use of traditional teaching methods. There was no systematic program to scaffold their pedagogical knowledge. Additionally, the teachers served large classes and did not have assistants.

To exploit this constraint, ZTF could systematically train the teachers in the use of XO computers, application of active pedagogy such as PBL, and ways to put students at the center of the learning process and to incorporate XO computers into the lesson design. The school could reactivate the pedagogical circles. In this lapsed practice, the teachers met one Saturday a month to discuss and share tips to improve their pedagogy performance. There were not external resources to pay for teachers' assistants, but students could serve as mentors and provide peer-to-peer education that could helpful for students and teachers.

To subordinate and synchronize the constraints, the school could rely on ZTF's support and teachers' own expertise to empower children to become mentors. To elevate the performance constraints, the school could implement a program to promote mentorship and organize a committee with volunteers from local and international universities with education programs who could contribute to achieving the goal to overcome the pedagogical constraints.

4.5.3 CHILDREN'S WELL-BEING CONSTRAINTS

I identified constraints related to children's well-being that affected student performance. However, children's nutrition was not a priority at the school. A food stand in the school called a *glorieta* served as an informal cafeteria selling carbonated

beverages, snacks, and fruits. It did not support a healthy diet for students or school staff. In addition, the school's relationship with the community was limited to its relationships with the teachers and students.

To exploit these constraints related to nutrition, the food staff should be trained in nutrition facts. To subordinate and synchronize the constraints, the school could create and promote an internal campaign to stimulate healthy food consumption throughout the school community. To elevate the performance constraints, the school administrators could seek alliances with local universities with nutrition programs to advise them about the kinds of meals children and school staff should consume to stay healthy.

To exploit the community constraints, the school could expand its relationships with other schools in the sector to allow the teachers and students to have more access to ICT training. It bears emphasizing that unlike other countries where ZTF operated, students in Honduras could not take XO computers home because they lived in an area with a high crime rate. This limited the students from sharing this technology with their families and using it to do homework. Exploiting these constraints depended only on the school or ZTF; the external context also played a key role that would not change in the short term.

To subordinate and synchronize the constraints, the school and ZTF need to work together and engage in external collaboration to make the community safer. Elevating or eliminating the performance constraints is a challenge because a particular group of gangs control the area where the school operates. Residents from other areas are not allowed to cross other neighborhoods, and sometimes even attending a school in a different area could mean a threat to one's life. The school cannot change this situation alone; it needs the support of non-governmental organizations (NGO) and local authorities to develop community programs to increase student achievement and mitigate reduce factors (e.g., domestic violence, migration, poor nutrition, family disintegration, and child labor) affecting student performance.

4.6 FOLLOW-UP PHASE

After the analysis, I concluded the future workshop with the follow-up phase. I prepared a report describing every phase of the future workshop, discussed the findings with the ZTF executive director, and finally prepared a shorter version of the report for the school principal. The ZTF executive director expressed its commitment to equipping the school with XO computers and providing technological and pedagogical support to improve teaching skills and educational quality. However, ZTF lacked the resources to purchase new infrastructure or help fix other constraints the school faced. ZTF's goal was to provide quality education and technology access for children with limited resources, so in this sense, the scope of my investigation was limited to identifying the constraints and co-designing with the practitioners an

educational model integrating ICT and an active pedagogy for use in the classroom. I decided the next steps with the ZTF director and the school principal, and we defined an action plan to train teachers in PBL principles and XO activities.

4.7 DISCUSSION AND CONCLUSIONS

Despite the social context, the whole school was equipped with XO computers provided by ZTF, a non-profit organization sponsored by Lafise Bank and other private-sector companies engaged in CSR. The data collected shows that technology by itself cannot solve social and pedagogical problems; quite the opposite, it can add more problems. In this case, the use of XO computers in the classroom as didactic tools has not been standardized in practice but left up to the teacher whether to integrate it. Combining the usage of XO and PBL could help bridge the technological gap and equip children with new skills to face the challenge of the 21st century (Chapter 2).

Physical and non-physical constraints prevented the teachers from delivering quality education in the classroom. The challenge for teachers is to properly use ICT and pedagogy to enhance children's learning process in line with the demands of the 21st century. Doing so requires the creating an educational model designed to integrate XO computers and student-centered learning to overcome some constraints identified in this study (Figure 43). However, other constraints require further analysis.

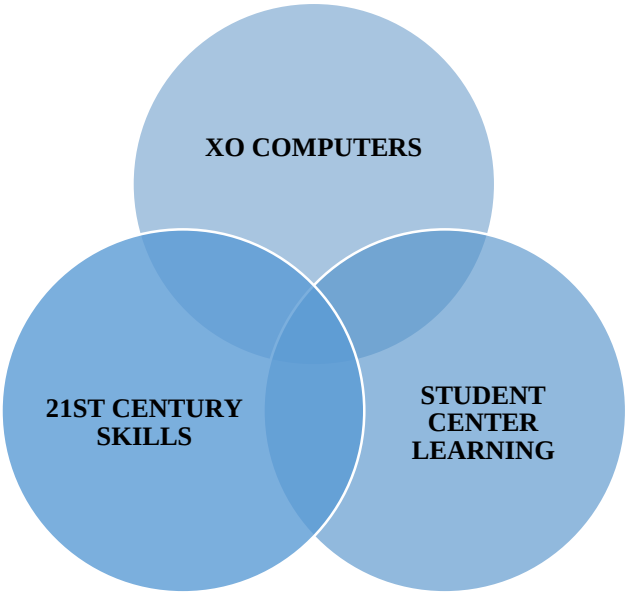

Figure 43. Aspects to incorporate in the design of an educational model

Introducing a different way of teaching to improve children's learning experience by using XO computers requires establishing innovative solutions by identifying what pedagogical factors need to be changed and understanding what to change and how to effect change (Goldratt, 1990). In chapters 5 and 6, I describe the design and construction phase and propose a student-centered pedagogical model including ICT.

CHAPTER 5. GENERATING IDEAS FOR DESIGNING POTENTIAL SOLUTIONS

The second phase of EDR is design and construction (McKenny & Reeves, 2012). In this chapter, I focus on design. The second part, construction, is addressed in the next chapter.

With the participants' inputs and ideas, I explored the design of potential solutions to integrate technology and active learning into the classroom. I implemented TOC thinking process based on cause and effect logic (TOC Institute, 2017). Furthermore, I introduced the pedagogy of the oppressed categories (Freire, 1970) to pinpoint the core problems because this research was carried out in a deprived community. I responded the questions as follows (Goldratt, 1990):

1) What to change? Pinpointed the core problems

2) To what to change to? Constructed simple, practical solutions

3) How to cause the change? Socratic method

5.1 WHAT TO CHANGE?

To come up with ideas of what to change, I first examined the undesirable effects or core problems. The effect–cause–effect method is an appropriated technique to pinpoint core problems. "The process of speculating a cause for a given effect and then predicting another effect stemming from the same cause is usually referred to as Effect-Cause-Effect" (Goldratt, 1990, p.32).

I studied the effects caused by the traditional way of teaching and the usage of XO computers in the classroom. I used Freire's (1970) learning theory attempting to reconcile teacher–student contradictions based on practices and attitudes mirroring the oppressive society and stimulating banking education. Freire (1970, p. 59) categorized ten aspects that stimulate these contradictions: "1) the teacher teaches, and the students are taught; 2) the teacher knows everything, and the students know nothing; 3) the teacher thinks, and the students are thought about; 4) the teacher talks, and the students listen meekly; 5) the teacher disciplines, and the students are disciplined; 6) the teacher chooses and enforces his choice, and the students comply; 7) the teacher acts, and the students have the illusion of acting through the actions of the teacher; 8) the teacher chooses the program content, and the students (who were not consulted) adapt to it; 9) the teacher confuses the authority of knowledge with his or her own professional authority, which she and he sets in opposition to the freedom of the students; and 10) the teacher is the subject of the learning process, while the pupils are mere objects."

5.1.1 PINPOINT THE CORE PROBLEMS

From my data, I identified 6 of 10 contradictions described by Freire (1970, p. 59) in *Pedagogy of the Oppressed*. Taking this as a reference, I examined the effects caused by the traditional way of teaching and the usage of XO computers in the classroom.

Freire's (1970) categories	Categories identified in my research
(a) "The teacher teaches, and the students are taught."	X
(b) "The teacher knows everything, and the students know nothing."	X
(c) "The teacher thinks, and the students are thought about."	X
(d) "The teacher talks, and the students listen meekly."	X
(e) "The teacher disciplines, and the students are disciplined."	X
(j) "The teacher is the subject of the learning process, and the pupils are mere objects."	X
(f) "The teacher chooses and enforces his choices, and the students comply."	Not applicable
(g) "The teacher acts, and the students have the illusion of acting through the teacher's actions."	Not applicable
(h) "The teacher chooses the program content, and the students (who were not consulted) adapt to it."	Not applicable
(i) "The teacher confuses the authority of knowledge with his own professional authority, which he sets in opposition to the freedom of the students."	Not applicable

Table 22. Teacher–student contradictions (Freire, 1970, p. 59)

5.1.2 THE TEACHERS TEACH, AND THE STUDENT IS TAUGHT

According to my observations represented in a process chart (Figure 30) on the traditional science lesson delivered to the third graders (Chapter 4), the current educational design maintained a vertical relationship. In a typical class, the teacher's role was to deliver information to the students, who listened and followed the teacher's instructions. When I was observing the class, the students did not ask any questions or comment on anything to the teacher. Even when the teacher used kind words, such as *amores* (loved ones) and asked if they had any question, the students remained quiet, looking at the teacher and each other.

The teachers made much efforts to speak loudly enough to reach large groups of around 45 students in small classrooms. Even when all the children had XO computers on their desks, the students used them as an external tool to respond specific questions rather than as part of the lesson plan. The teacher stood in front of the classroom teaching the lesson in an instructional way. She asked questions about the lesson from

the day earlier, and the students were expected to memorize what they learned. The teacher asked questions related to the topic, but only a few students could answer. The rest looked disconnected from this activity.

This traditional way of teaching had undesirable effects. I interviewed Joel López, a fourth-grade teacher, who explained how he organized his class every day: "I try to combine my class. I like to make lectures, but also I try to make them work in groups. I like that they learn by doing. I also learn, and they learn as well. I follow the national curriculum that is very traditional, but I find that teamwork facilitates the learning in my classroom. Even when I want to do more with my students, there is not enough space in the schools. We don't have a library. We have limited access to the community because it is dangerous. However, I took them to museums and organized field trips to Copan Ruins [archaeological ruins of an ancient Mayan city], for instance, to teach them more about the Maya civilization."

According to Freire (1970, p.59) when "the student is taught," children are not empowered to learn by themselves. The data collected during the future workshop (Chapter 4) showed that one of the teachers' main constraints was that their pupils could not answer analytical questions and had literacy problems. During the workshop, the teachers identified these negative effects that they had to handle and said that they did not know how to improve this situation.

5.1.3 THE TEACHER KNOWS EVERYTHING, AND THE STUDENTS KNOW NOTHING

Freire (1970) claimed that in banking education, teachers are the center of knowledge and transfer all this knowledge to the students. During the interview, Joel López called for more training. Teachers attended workshops twice a year to improve their technological skills using XO computers. He, though, thought that "this is too fast for me. We need to be trained frequently as part of a long-term program. One or two days is too fast. We need to receive more feedback and share more our experience with other teachers."

Reflecting on this situation, another teacher Gloria Hernández expressed that she was surprised that "many students are faster understanding how to use the XO than us. Once they understand how it works, they even teach us and help other students." Hernández thought that children were discovering the potential uses XO computers to do research and to actively engage students in the learning process but still had much work to do in this area. She agreed that the teachers tended to blame the students if they were not learning in appropriate ways, and the educational system put more pressure on the teachers if the students failed or dropped school, even when the teachers were not properly trained with active pedagogy and technological skills.

The assumption that "students know nothing", Freire (1970, p. 59) put more pressure on the teachers and did not allow them practice critical thinking or establish permanent dialogue with other teachers and peers to find solutions to real-life problems. "Without participatory dialogue, learning remains removed from an individual's experience and mental connections. Learning that takes place without personal connections is elusive and difficult to retain" (Ronis, 2007 p.56). During my classroom visit, I observed that education in this school was a top-down practice, and the teacher had the primary responsibility for knowing the subjects and transmitting the information during the learning process carried out in the classroom. The students were not expected to build their own knowledge but simply to follow the teachers' instructions, be quiet, and allow the teachers to fill in the empty vessels of their brains with information. The teachers could not be blamed for thinking that the students knew nothing because this was an old teaching practice, and the traditional school system did not allow educators and students to work together to shift the paradigm and become active learners.

5.1.4 THE TEACHER THINKS, AND THE STUDENTS ARE THOUGHT ABOUT

There was vertical interaction between the teachers and students. In the classroom, the students sat in rows and repeated and memorized the lesson. The teacher delivered the content to the students but did not connect the information to problems or integrate use of XO computers into the lesson plan. Students tried to memorize the content, but the narrative and the meaning were disconnected from their reality. In this interaction there is a vertical interaction between teacher-student, Shim, (2007) points out Freire`s belief that teaching and learning process is an oppressive situation, "he demonstrates the narrative character of the teacher-student relationship, in which the teacher infuses a static content of information into the student." (p. 527)

5.1.5 THE TEACHER TALKS, AND THE STUDENTS LISTEN MEEKLY

A culture of silence is part of banking education. The students play a passive role, while teacher knows everything, selects the contents, and talks. The students do not come to know anything but only listen and comply. Teaching as banking dehumanizes learners because it blocks their autonomous and critical consciousness through which they try to participate in and transform the world.

In this school context, the teachers had an active role and primary responsibility for delivering the content, while the students played a passive role. However, I observed that most students had difficulty remaining quiet and listening, and the teachers put a lot of efforts into trying to capture the attention of the children in the large groups they served. The teachers wanted to change this situation and get students involved but did not know how to start. The data collected during the fantasy phase of the future workshop showed that one main struggle teachers faced was trying to keep the

students' attention. The teachers invested much time in disciplining the students to keep their attention. The teachers wanted to change this situation and have fewer students in the classroom. The teachers' drawings (Figure 44) represented their desire to have a smaller group of students in digital classrooms. Group No. 1 in the morning session wanted to have a medium-size group, with around 35 students. Group No. 1 in the afternoon session wanted a smaller group, with a drawing showing 12 students sitting in rows, one after another, and working individually, but the technology was at the center of the learning process. While group No. 3 drew 25 students and put students at the center of knowledge.

Figure 44. Teachers' drawing representing their desire to have medium-size groups and contact with psychologists to deal with children's misconduct / Teachers' drawing representing their desire to have smaller groups using XO computers properly, air conditioning,

5.1.6 THE TEACHER DISCIPLINES, AND THE STUDENTS ARE DISCIPLINED

I participated as observer and video recorded a science class (Chapter 4). On the video, I captured how the teacher managed the classroom and how the students behaved during the class. Applying visual anthropology principles to the following scenes taken from the video footage, I analyzed a typical day in the teaching–learning process.

Figure 45. Students forming a line to enter the classroom while the teacher gives them instructions to follow

Figure 46. Students standing in rows and praying "Our Father" before the lesson

The teacher served 45 students. The temperature in the classroom was 25–40 degrees Celsius year-round, and the classroom had two ceiling fans. The teacher tried to capture the students' attention while reviewing the previous class lesson. I registered the following dialogue between the teacher and students.

Teacher: "Please, if you are talking, we are not going to listen each other. Slowly and quiet, start looking for your material. This is a review of the class before which was about the main part of the nervous system?

Students: "The brain." A child replied after other children came up with the wrong answers.

In this interaction between the teacher and students, there was a lot of noise from the students and from outside. Some students were still looking for a space to sit, and two students appointed by the teacher were responsible for taking out the computers from the lockers and delivering them to the other students. This process took around 20 minutes due to the large number of students, which disrupted the start of class until they all were set up with their XO computers.

Figure 47. Children receiving XO computers while the teacher starts class and demands their attention

The teacher kept going with the class, trying to take control, and asked the students questions related to the subject.

Teacher: "What do you think the brain is? Please, listen." Some students tried to answer at the same time, and the teacher asked one girl to speak up.

Student: "When someone pulls my hair, my brain hurts"

Teacher: "But ... what is the brain?" Suddenly, the teacher moved from teaching to disciplining and spoke loudly. "Let's see, you guys in the back, what's happening there?" Those students were not paying attention to the class at all.

This classroom management emphasized a behavioral approach, and the teacher tried to control the class by keeping the students quiet and paying attention. The relationship between the teacher and students was top-down. There are connections between banking education (Freire, 1970) and the behaviorist learning of theory (Skinner, 1974): this approach favors passive learners, teachers are the main authority and set the rules the students must follow, or the students are punished or rewarded by the teacher accordingly. In this school, one way to reward students was to let them use XO computers to play games after completing their assignments. One common way to punish students' misbehavior was to prohibit them from going to recess.

As Landau (2009, p. 740) pointed out, "If teachers believe that students serve as vessels waiting to be filled with content knowledge, then their approach to classroom management very likely will be authoritative and their ultimate goal will be to have quiet, obedient students who listen to lectures and perform tasks as instructed. And then there are other teachers who believe learning is a shared process of discovery. Accordingly, their approach to classroom management is characterized by egalitarian practices and their ultimate goal is to use problem solving and reflective thinking both as processes that support a well-managed classroom and processes that support effective content acquisition. The first approach is commonly referred to as behaviorist and the second as constructivist or democratic."

In this research, most of the students came from unprivileged families, and their parents lacked formal education. These circumstances led the teachers to assume that active learning would be more difficult to carry out in the classroom, even though they realized it was the best way to educate children. I have not intended to blame the teachers for implementing traditional pedagogy but to examine the undesirable effects and investigate the causes of this teaching practices. As presented in Chapter 4, the teachers faced poor infrastructure, classes with large numbers of students, and a lack of training to improve their pedagogical skills every day. Moving to a constructivist or democratic paradigm to manage the class would require equipping the teachers with a new mindset, increasing dialogue, and using technology to integrate a participatory approach.

5.1.7 THE TEACHER IS THE SUBJECT OF THE LEARNING PROCESS, AND THE PUPILS ARE MERE OBJECTS

There was tension between the use of pedagogy and technology in the classroom. To understand this situation, I asked some teachers for their opinions regarding the role of educators and children in the classroom.

Extract from the interviews:

Teacher 1: "Many of us [teachers] are using this [XO computers] as an instrument. We are inserting the child into a new era. XO is a constructivist tool."

Teacher 2: "There are cases of children searching on the Internet, and they found pornographic images. We should remember that our children live in marginalized urban areas, in overcrowded conditions, and probably they just will do what they have already witnessed."

Teacher 3: "No child reaches school in zero [without previous learning]. If a child reaches school in zero, for example, he would not be able to leave his house and walk to school. I am wondering how he remembers his own name and their classmates. If you ask him to describe a trip, he will tell us in detail how the trip was. A child does

not come to school without previous knowledge. The problem is that we [teachers] think that children do not know anything. We do not realize children's potential, and later over time, those children become passive."

From this dialogue with teachers, I learned that they think that students could manage knowledge, but the education system turned them into quiet listeners. Freire's (1970) theory support that learners in such contexts are taught to remain passive. They do not receive scaffolding to bridge learning gaps to help them develop critical thinking skills to break the circle of ignorance. In elementary schools based on traditional pedagogy, children receive repetitive instruction and are forced to memorize lessons. Discovering and curiosity are not part of the class design. Although in this school all the teachers and students were assigned XO computers, the teachers interviewed required more training, because most children learned to use the technology faster than the teachers. Freire (1970) strongly criticized banking education, which he argued puts the student in a submissive role, where the only one who has knowledge and authority is the teacher. This school adopted a top-down approach to teaching in which the teacher was the subject, and the students the object of the learning process.

5.1.8 REFLECTIONS ON POTENTIAL EFFECT–CAUSE–EFFECT

Although the teachers had appropriate technology to use in class, they did not take full advantage of it, and the banking concept in the learning process still prevailed. A top-down relationship between mentors and pupils dominated, affecting the possibilities to collaborate in such a way as to scaffold the students with new skills required in the 21st century. In this context, the educators were conditioned to implement a teacher-oriented pedagogical model, all the responsibility rested on them, and the students expected the teachers to know everything and did not assume an active role in the learning process. Consequently, the teachers were irreplaceable, and technology would not eliminate them; however, they had to assume new roles as facilitators of dialogue, reflection, and feedback. Even in this school in a deprived community, a student-center approach could be introduced using technology, allowing children to become the center of knowledge.

To What to Change to?

In the previous section, I explained the effect–cause–effect method to understand how teacher-oriented practice negatively affected the students' attention and participation. XO computers in the classroom were not sufficient to keep the students and teachers focused in an active learning process.

In this section, I attempt to present ideas using a thinking tool proposed by TOC: evaporating clouds or a conflict resolution diagram. This is a method to look for simple solutions, induce people to participate and re-examine the foundations of their system, and create a new environment in which the problem cannot exist (Goldratt,

1990). Gupta and Kerrick (2014) claimed, citing Dettmer (2003) and Gupta and Kerrick (2011), that "the evaporating cloud is a structured and comprehensive approach to identifying and presenting various elements of a conflict situation, identifying underlying assumptions that cause the conflict to continue to exist, and developing injections that can invalidate one or more of the assumptions."

According to Goldratt (1990) the evaporating clouds is a graphic representation intended to reveal not a solution but the core problem to make disappear or vanish:

1) A: This is the goal to accomplish. B and C are needed to accomplish this goal.

2) B: Satisfying B is a prerequisite to satisfying D.

3) C: Satisfying C is a prerequisite to satisfying the opposite of D.

4) D: This the opposite action to continue rather than deal with the problem.

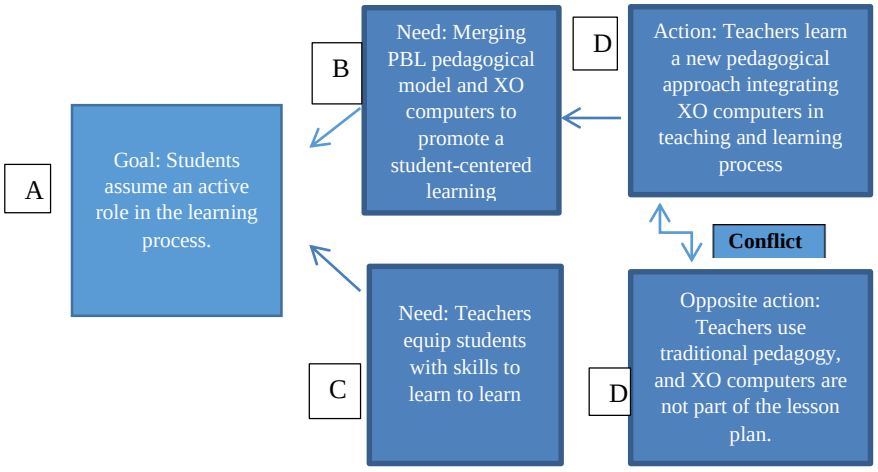

Figure 48. Using evaporating cloud representation to summarize the answer to what to change in the classroom during this research

As represented in Figure 48, the answer to what change can be summarized thus: The goal is to allow the students assume an active role in the learning process, merging the PBL approach and XO computer to promote student-centered learning; to train teachers to be able to equip students with the necessary skills to face 21st-century challenge; and to eliminate the conflict between traditional and nontraditional teaching.

5.2 HOW TO CAUSE CHANGE?

5.3.1 SOCRATIC METHOD

In the previous section, I answered the first two questions: What to change? To what to change to? In this section, I explore how to cause the change. To respond this question, I used the Socratic method suggested by Goldratt (1990) as an approach to overcome the participants' resistance to change. I chose to use this method to overcome the emotional resistance to shifting the educational paradigm. I opened the dialogue with an open question on how to break the cycle of ignorance in the school community, not only in the classroom but also considering the role of the parents and guardians in charge of the children at home. The teachers opened up quickly, expressing their opinions on how to transform the educational system, shifting to a completely other way of thinking to make changes possible.

I registered the conversation by taking notes. I did not use a video or audio recorder because I wanted to create a natural atmosphere where teachers felt free to discuss and suggest solutions. The dialogue participants included seven teachers, five women and two men, and a ZTF representative. I do not mention them by name to keep their identities anonymous, as requested. However, they very openly expressed how they felt and could make changes to improve this situation. After the dialogue, I summarized the outcomes from this interaction with the participants, who took ownership of what they proposed and became more engaged in making the changes needed. "The Socratic method is discussed as a way to overcome resistance to change. Using this approach involves asking questions that help a person invent their own solutions" (Wang, 2011, p. 178).

5.3.2 DIALOGUE TO EXPLORE SOLUTIONS

The Socratic method allowed revealing new information the participants had not yet shared and validated previous information. In the beginning of the conversation, the participants discussed their own experiences working with parents and reported that some parents could not read and write. Some teachers said they realized this when they sent letters and notes announcing school events to parents or guardians or communicated about a particular student's situation. The parents could hardly understand the message because they barely knew how to write and read, which it made it more difficult to them to educate their own children. Teachers came up with a solution and proposed holding classes for adults to improve their own reading and writing skills, so they could help their own children. In this dialogue, I encouraged the teachers to propose solutions and open their mind to innovative alternatives. During this process, the teachers in the upper fifth and sixth grades inevitably blamed the teachers in the lower grades for promoting unprepared students to the next grade. However, the teachers in the lower grades, in turn, blamed the national educational system for putting pressure on them to give the students more opportunities to pass

courses and to use minimal criteria for grade promotion. In this conversation, the ZTF representative stated that the teachers were responsible for ensuring that each child passing to the next level had fulfilled all the requirements.

A fourth-grader teacher had three students who could not read and write. She proposed changing the current methodology to help illiterate students and instead developing a special program training children as tutors for disadvantaged students. A third-grade teacher similarly proposed creating an internal mentoring program to train students as tutors using PBL as a pedagogical model. One teachers implied that PBL and XO computers could spur a collaborative environment in which students supported disadvantaged students to overcome literacy challenges, which was the main difficulty they faced in the classroom.

Even when I tried to conduct the dialogue looking for solutions, one teacher kept expressing regret that most parents did not get involved in their children's learning. As she talked, she looked defeated and hopeless and conveyed a feeling of powerlessness before this situation. In her fourth-grade classroom, 10 students faced illiteracy problems and could not read or write. The rest of the teachers kept quiet and focused on listening to her. Some tried to encourage her, telling to be patient and keep positive. Ultimately, they agree that they must work harder with large groups of students, around 45 children per classroom, amid poor infrastructure and daily temperatures exceeding 35 degrees Celsius, which made it difficult to keep classes under control and sometimes left them feeling frustrated.

Furthermore, the participants discussed the external context affecting the learning process, as mentioned during the future workshop (Chapter 4). They believed that it was not possible for them to solve external factors, especially those related to dangerous neighborhoods, with high rates of crime, poverty, and broken families. They pointed out that as educators, they could strengthen the students' mindset in the classroom, so they could learn to navigate and solve real-world problems.

In the last part of the dialogue, I guided the participants to reflect on how the alliance with ZTF helped achieve the school's educational goals. I found that they highly valued ZTF's efforts to provide XO computers for all the students and teachers. The participants recognized how important it was to keep this strategic alliance, and they suggested reactivating the pedagogical circles to update their pedagogical skills and adopt PBL principles, which they believed motivated teachers and students in the learning process. The participants also proposed adopting a peer-to-peer model to overcome the lack of teachers' assistants, especially with large classes.

5.4 REFLECTIONS ON HOW PROBLEM/PROJECT-BASED LEARNING PROVIDES STRUCTURE GIVEN THE CONSTRAINTS

The overall goal of my research was to identify and analyze the main constraints to applying PBL principles by using XO computers. I chose Freire's (1970) categories to explore the causes and effects of the current way of teaching in the classroom in which technology is used to reinforce knowledge but not to gain new knowledge. Children attending this school lived in poverty in marginalized areas and lacked family and governmental support to promote their social mobility. They had more disadvantages than upper-class children and had to deal with external factors, such as violence, family disintegration, low income, and malnutrition. For these children, school was their main opportunity to understand and face the world in a different manner, find opportunities, and experience love and respect from their peers and teachers.

Teachers, however, taught in a traditional way and struggled with the lack of resources and training to provide a quality education in the classroom. Even when all the children and teachers had XO computers, the teaching model was based on banking education, and teachers were missing opportunities to innovate with a student-centered approach integrating XO computers as didactic tools to scaffold the students. Teachers assumed that the children were not ready to become the center of education even when the dynamics between the teachers and students put more responsibility on the teachers. The teachers' goal was to achieve the curriculum objectives, and they viewed the students as the object, not the subject, of the learning process. The teachers were not taking advantage of the students' potential to become self-driven.

The educators were not empowering students to discover and find their own way to learn to learn. The students had to memorize content without developing critical thinking or collaborative skills. The way of teaching was frozen in the 20th-century scenario and did not equip students with the 21st-century skills. Teacher–student interactions were vertical, and it was assumed that the students needed to be disciplined rigidly because most lacked this kind of discipline at home. I observed that the children remained quiet during the class, only the teacher talked, and the students rarely got involved in the discussion. In the Honduras context, keeping silent while an adult talks was a sign of respect, but in this context, it could indicate an absent mind or fear of authority.

In conclusion, incorporating PBL principles and using XO computers presents a way to break vertical model, where students are only filled with information and lack practical application and critical thinking. Building an active model of learning might help bridge this pedagogical and technological gap and overcome the lack of appropriate infrastructure and textbooks. The teachers need to be trained to incorporate new pedagogical skills integrate technology as a pedagogical tool that allows the children to take greater responsibility for their learning. The teachers' goal

should be to equip the students with the necessary skills to face the real world and to transform their negative circumstances into opportunities to evolve as successful human beings. In the next chapter, I present in detail the construction of a learning model to integrate PBL principles and the use of XO computers co-designed with the practitioners using the inputs expressed in the previous chapters.

CHAPTER 6. DESIGN AND CONSTRUCTION: IDEAS AND SOLUTIONS

In this chapter, I describe through my own reflections the process followed to design and a construct educational design for use in this particular school setting. I based my thoughts on Freire's (1970) and Dewey's (1916) educational values of freedom and democracy. I describe the process I followed in the investigation and reflect on the prototype construction, which involved the literature review and empirical work with the practitioners.

6.1 REFLECTION ON CONTEXT DESIGN

I do not pretend to have reflected on national educational policy. Instead, I found it more worthwhile to reflect based on my grounded experience in the classroom, in which I had an active role observing, interviewing, and developing workshops with the teachers and learning through the students' experiences. Doing research in this school, I had to confront the risky life the students faced every day in their neighborhoods. As stated in Chapter 4, most children walked through dangerous neighborhoods in the control of dangerous gangs. They lived with extended families, and most did not receive any help at home to do their homework or have access to computers or the Internet at home. In addition, magazines, newspapers, and books were difficult to find in the neighborhood, and most residents could not afford to buy them.

I unfold a worst case; whatever improvement works here likely will work everywhere with similar characteristics: low-income families, criminality, and impoverished schools. The external environment affects school performance; discipline in the way taught in the classroom is not enough. The children need to learn to have self-discipline—but not in a punitive way; they need to be motivated to become well integrated into society. It is important that they can understand their reality and build self-confidence and positive self-image so that they can to transform their circumstances. Beyond providing technology, I perceive an urgent need to help the children to liberate themselves from the chains of poverty and insecurity. As Freire (1970, p.66) proclaimed: "Liberation is praxis; the action and reflection of men upon their world in order to transform it. Those truly committed to the cause of liberation can accept neither the mechanistic concept of consciousness as an empty vessel to be filled, nor the use of banking methods of domination (propaganda, slogans-deposits) in the name of liberation."

Conducting this research with children living under poverty, I observed that public education system in low-income areas dehumanizes students (Chapter 4) and puts them in a non-human category, in spite of teachers and NGO`s efforts still there is a gap to bridge, the absence of the national government need to be filled in an appropriate way. I agree with Freire when he states that people living in slums are not considered human beings. "For the oppressors, "human beings" refers only to themselves; other people are "things." For the oppressors, there exists only one right: their right to leave in peace." (1970, p. 43) Without consciousness, individuals are easily manipulated by populist leaders and the elites, and this domination unable them to transform their reality. "The dominant elites utilize the banking concept to encourage passivity in the oppressed, corresponding with the latter's "submerged" state of consciousness, and take advantage of that passivity to "fill" that consciousness with slogans which create even more fear of freedom." (1970, p. 84)

In the traditional model, the learning process falls on teacher's shoulders. This kind of system reduces children's capacity to understand and transform their own reality. Schools miss important opportunities to help children transform their adverse circumstances. As Dewey (2007/1916, p. 50) stated, "It is not of course a question whether education should prepare for the future. If education is growth, it must progressively realize present possibilities and thus make individuals better fitted to cope with later requirements." According to my observations, one way to help students to liberate themselves is to equip them with critical thinking skills and help them become active subjects of learning, able to construct their own knowledge. I was disappointed to find out that children are growing up unattached to their community, and their own families do not support their success. They are condemned to intergenerational poverty.

Most children attending this school came from families whose main challenge was to survive on an everyday basis and to obtain the necessary resources to meet their basic needs, such as food, shelter, water, electricity, and transportation. For most students, schools should offer the safest place to be, a neutral space free of violence and poverty. For instance, wearing school uniforms gives them a sense of belonging, provides a fair environment, and reduces the cost of buying clothing to attend school. Another important aspect is to promote healthy parent–child relationships to prevent children from being recruited into criminal gangs, prostitution, and drug trafficking, among other social threats.

Students living in complex environments demand more efforts from teachers and administrators because they do not receive support from their parents or other relatives to perform tasks and do not have access to books and Internet at home. For instance, when teachers assigned homework, most students did not do it. According to the teachers interviewed, the students; main reason was that they did not how to do it by themselves. Such simple tasks as cutting magazines or newspapers were not performed, and most students did not do more complex assignments, such researching

a particular subject. Teachers believed that it was better to allow students to use the computers during class, but use of XO computers was not integrated into lesson planning.

Children bring to school much stress transmitted by their family environment. This often makes the teachers' job more challenging because they need to keep the students focused on the school goals. While observing the classes, I saw how the students got excited when they were instructed by the teacher to finish their assignments using XO computers, and the teacher promised that they would be allowed to play with the XOs applications afterwards, which served as a reward for the children. According to my observations and teachers' interviews, using XO computers reduced absenteeism, and the students came to school more motivated. Using XO computers appropriately then can mitigate the negative effects of absenteeism and increase student retention.

Implementing active learning in the educational environment goes beyond transferring knowledge to empowering students from childhood, strengthening their self-esteem, and promoting social mobility by equipping them to become skilled employees, able to integrate into the qualified labor force but also to experiment with innovative entrepreneur skills. Teachers and students are immersed in external environments featuring violence, economic scarcity, and a lack of values. Teachers do not receive formal training to face these challenges. Incorporating the use of computers in the classroom opens new learning opportunities for the children, and teachers must facilitate this process with revolutionary leadership. Teachers are crucial in this process but need to assume revolutionary leadership and contribute through small but significant changes, starting in the classroom. In this approach, the top-down model of education should be abandoned. Students should be involved in the process and adopt more active roles, able to develop habits, attitudes, and aptitudes fueled with moral values and democratic feelings.

Using machines to boost the teaching–learning process is not new to the educational field (Cuban, 1986; Maier & Warren, 2000), not is implementing pedagogy to free the oppressed (Freire, 1970). However, in my research context, the integration of active learning and XO computers can innovatively shape the educational environment. XO computers are artifacts that can be used as a toolbox with 64 activities to be applied in different school subjects. Furthermore, XO computers enable communication (e.g., chat, emails, and messaging forums) and have didactic tools, CD-ROM players, Internet access, online journals, and learning materials. Teachers should exploit students' interest and incorporate their experience. Since infancy, students have had growing capacities, talents, habits, attitudes, and aptitudes that could led them to develop democratic feeling and morality (Dewey, 1916).

6.2 HOW WAS DESIGNING IN THIS CONTEXT FOR ME?

Context is relevant to the learning process. “We need to reconnect technology, learning and context in the way in which we design and use technology to support learning” (Luckin, 2010, pp.17-18). First, I explored the external context to understand the everyday challenges that students faced in their neighborhood and family environment. Second, I explored the school’s internal context, particularly the infrastructure, technology, and teaching practices. Instead of blaming the educational system, I sought to understand this particular school setting and worked with school and ZTF staff to generate ideas and explore solutions to understand the constraints to applying PBL in this landscape and the current traditional, top-down, way of teaching. On one visit to the school, a teacher drove me in her car and told me that driving this route was part of her daily life routine. She felt some fear because the school was in a neighborhood controlled by different gangs. However, she also felt safe because the criminal groups usually respected teachers because some children attending school were their relatives. This dangerous external environment through which most children walked to reach school, usually with other peers or relatives, had become part of their lives, and despite it, the school had high enrollment. Although significant numbers drop out of school, most managed to complete elementary school.

Furthermore, I observed that the students in this school did not rely on a family structure to motivate them to keep studying. The teachers interviewed told me that when they invited parents or other relatives responsible for the children, most did not attend school meetings. The parents could barely read and write, so it was difficult to keep them informed through these means.

Taking into consideration this context, I propose to strength a microsystem I call Inside–Outside. It starts inside the classroom, replacing the absence of the national government with the support of NGOs, and the lack of family support is replaced by teachers and peers. It is then extended outside as children expand their new knowledge, positively affecting their families and the communities where they live.

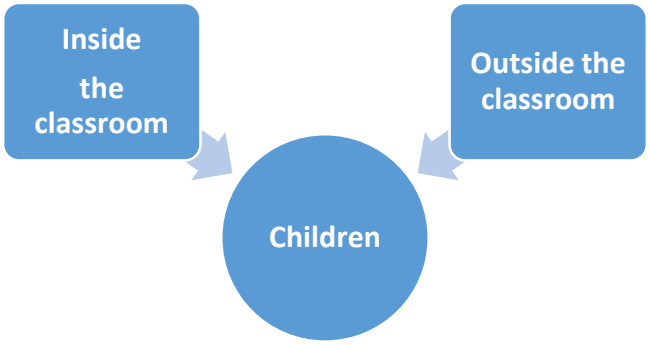

Figure 49. Inside–outside microsystem to support children’s education

This Inside–Outside microsystem (Figure 49) should allow children to liberate themselves from an unfair system that pushes them back and condemns them to remain ignorant. As Freire (1970) claimed, the need is to liberate the oppressed through a non-banking education, not through a repository of knowledge.

6.3 FOLLOWING THE DESIGN-BASED RESEARCH METHODOLOGY

I followed DBR as a methodology to work with practitioners in the classroom. I used the inputs from the first phase of this research (analysis and exploration) to design and construct potential solutions to the research questions posed during the design of the research (McKenney & Reeves, 2012). As stated in my reflections, integrating technology goes beyond using computers as tools to learn and implies accepting shifting from a top-down educational paradigm to a different one based on active learning that can transform students' mindset (Thompson, 2000). Designing in this particular school's context made me realize that to transform and reshape the school's learning environment, I had to take into consideration the teachers' and children's pedagogical, technological, and social challenges.

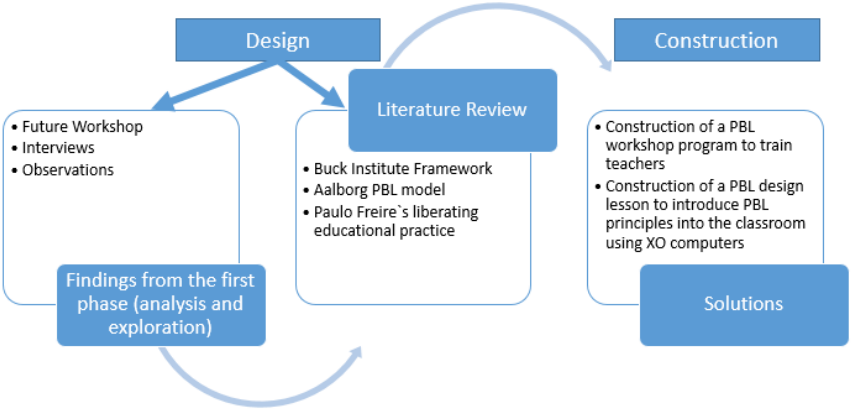

Figure 50. Design and construction process using design research principles

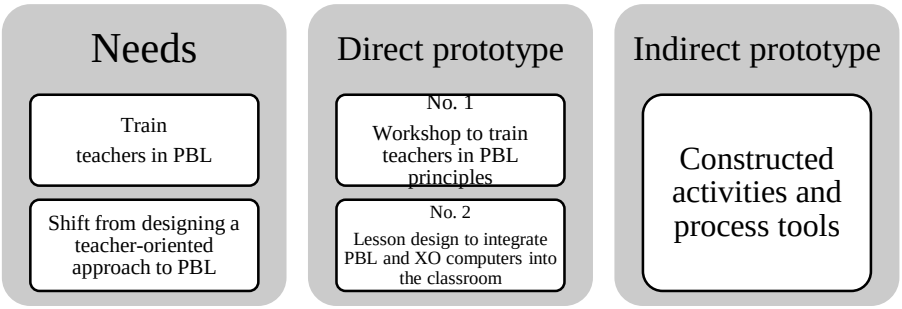

Figure 51.Direct and indirect prototypes created to respond the main constraints identified based on education design research (McKenney & Reeves, 2012)

6.4 A PROTOTYPE CONSTRUCTION PROCESS

In my research, I used the term *prototype* to describe a lesson design model. According to McKenney & Reeves (2012, p. 125) prototypes can encompass a wide range of artifacts, such as software, books, websites, and so on." The process of build the prototype is represented in Figure 50. During the design phase, the main inputs came from the future workshop, interviews, and observations. I supported these processes with the literature review discussed in chapter 2, in which I described the theoretical framework of the BIE mode, the Aalborg PBL model, and Freire's educational theories.

Here, I summarize the main constraints identified during the first phase of analysis and exploration:

1) Pedagogical constraints: The teachers received very limited pedagogical training and kept teaching in a traditional way. There was not a systematic program to scaffold their pedagogical knowledge. Additionally, the teachers served large groups of children and did not have assistants.

2) Technical constraints: The Internet connection was weak, preventive maintenance of XO computers was lacking, and the school lacked the economic resources to pay for it.

3) Children's well-being constraints: These constraints affected the students' performance, but children's nutrition was not a priority in the school. A food stands inside the school called a *glorieta* served as an informal cafeteria selling carbonated beverages, snacks, and fruits. There was not healthy food for the students and school staff. In addition, the school's outreach to the community was limited to its relationship with the teachers, students, and teachers.

The data confirmed the teacher-oriented practices, the technological challenges the school faced, and the situation of social disadvantage the students faced to attend classes every day. Taking into account those conditions, a group of 16 teachers and I worked to create two prototypes: one to train teachers to introduce PBL into their classrooms using XO computers and one to trial and refine during the class implementation with students. These solutions were intended to meet the main needs identified in this research and to provide the kind of design needed to introduce PBL by using XO computers (Figure 51).

6.5 UNFOLDING THE TWO-DAY WORKSHOP TO DEVELOP THE PROTOTYPES

I carried out a two-day workshop on PBL principles on May 16 and 17, 2016, in the Lafise Bank conference room. The target group was 16 elementary school teachers. The general objective was to equip teachers with the necessary skills to design a lesson with PBL principles and use XO computers as didactic tools.

The specific objective was to:

1) Explain to the practitioners the theoretical and practical foundation of PBL and 21st-century skills

2) Co-design with practitioners a classroom lesson prototype to apply with third and fourth graders based on PBL principles and using XO computers as a teaching tool

I chose to start training the practitioners to build their student-center pedagogy skills and ultimately change their mindset. Table 23 shows prototype no. 1, which I constructed to train teachers, integrating PBL principles and ICT into the lesson design, especially the use of XO computers in the classroom. The goal was for the teacher to then be able to create prototype no. 2 (Tables 25 and 26), a lesson design to integrate PBL and XO into the classroom, responding to the need to integrate PBL as active learning and XO computers in order to equip students with 21st-century skills to be competitive in a globalized world.

6.5.1 FIRST DAY'S WORKSHOP

I constructed a lesson design prototype to train teachers based gold standard PBL (Table 13; BIE, 2015). I asked the teachers a driving question that required them to respond by designing a lesson using PBL principles, I divided the teachers into working teams grouped by the grade they taught (e.g., fourth-grade teachers were grouped together). They signed a collaboration agreement to work on teams. Table 23 shows a sample of a prototype to train teachers in problem/project-based learning principles.

Objective	Driving question	Activities	Tools to integrate PBL and ICT	Start date	Final date
Introduce PBL principles to teachers so that they can design a lesson incorporating PBL and ICT	How can a Spanish lesson using PBL principles and XO computers taking into account 21st-century skills be designed?	Divide the teachers into groups	XO computers PowerPoint Internet	May 16, 2016	May 16, 2016
		The teachers brainstorm on the feasibility of designing and implementing a lesson using XO computers and PBL.	Note-taking Google search	May 16, 2016	May 16, 2016
		The participants define the problem.	XO computer as a writing tool	May 16, 2016	May 16, 2016
		The participants research on PBL on the Internet and discuss their own ideas.	XO Internet Google	May 16, 2016	May 16, 2016
		The participants work with their teams and prepare a presentation of their solution to the problem.	XO-Conceptual map Writing tool	May 16, 2016	May 17, 2016

		Each team makes a presentation of their final solution.	Data display XO computers	May 17, 2016	May 17, 2016

Table 23. Sample of a direct prototype to train teachers in problem/project-based learning principles

The introduction of PBL as an active learning method was new for most teachers attending this workshop. Even when they told me that children should be central to the learning process, they still used teacher-center approaches. I, therefore, decided to deliver this workshop using PBL as pedagogical approach. The participants had a central role proposing ideas and sharing their concerns about the challenge they faced every day in the classroom. The empowerment experience was very important so that they could adopt PBL as a pedagogical approach in the classroom.

As facilitator, the first activity I conducted during the workshop was a short presentation on PBL. I introduced the key concepts summarized as follows.

Key questions	Key concepts
What is PBL?	According to De Graaf and Kolmos (2003), PBL places students at the center of knowledge and requires them to solve problems, work in teams, construct knowledge, and learn collaboratively (Chapter 2).
What are the PBL principles?	Principles: Collaborative learning: teams and participant directed Cognitive learning: problem, project, experience, and context Contents: interdisciplinary, exemplary, theory, and practice (Kolmos, De Graaff, Du, 2009, pp.11)
What is the role of the teacher?	The role of the teacher resembles that of a guide, facilitator, or project supervisor (Chapter 2).
What is the role of the student?	Through PBL, students learn by solving questions, completing tasks, applying new and past knowledge, and developing skills necessary to succeed in the 21st century. Students thus build knowledge and are more independent when inquiring about assignments (Chapter 2).
What is the role of ICT in introducing PBL?	Integration of PBL and ICT requires that lessons were designed taking into consideration aspects such as collaboration, teamwork, research, self-discovery, and critical thinking. The use of computers and the Internet can open access to many resources that the teacher must choose strategically to ensure that the students can connect what they are learning with the real world (Chapter 2).
How can the PBL lesson be designed and implemented?	Gold Standard PBL (BIE, 2015): Challenge problem or question

	Sustained inquiry Authenticity Students' voices and choices Reflection Critique and revision Public product (Chapter 3)
21st-century skills	Practicing pedagogy in the 21st century requires critical thinking, problem-solving, and communication skills to express oneself in different ways. Knowledge and collaboration thus are the main elements in learning to learn, to do, to live together, and to contextualize being (Chapter 2; Scott, 2015).

Table 24. Key concepts to introduce problem/project-based learning to the participants

The participants (Figure 52) themselves designed a prototype to apply PBL principles along with use of XO computers. They defined the problem and discussed what to do about it and what resources they would use to investigate the problem/project (e.g., XO computers and Internet access). They formulated the research questions, selected the resources to present their findings, and worked in groups collaboratively.

Figure 52.Participants working in teams using XO computers to research and prepare solutions

6.5.2 SECOND DAY'S WORKSHOP

The participants worked on their respective teams and presented viable solutions to the problem (Figure 53). Four projects resulted from this workshop, one for each grade represented (second, third, fourth, and fifth grades). After the group presentations, all the participants reflected on how they thought that PBL could be implemented in the classroom and how they felt about this new pedagogical approach. Some participants mentioned their fears of adopt PBL because it was new to them. However, they all

agreed that they had the technology, and it was necessary to change the teacher-oriented paradigm.

Figure 53. Teams presenting the viable solutions

During this workshop, the teachers developed two prototypes to implement in the classroom. I worked with the practitioners constructing two prototypes for third graders and fifth graders studying Spanish. However, these prototypes were designed to be completed during the implementation in the classroom, as presented in tables 25 and 26.

I asked for volunteers to participate in the implementation. Two teachers, one from third grade (morning session) and one from fourth grade (afternoon session), volunteered to be part of this design experiment. As Cobbs et al. (2003, pp.11) pointed out, "a primary goal for a design experiment is to improve the initial design by testing and revising conjectures as informed by ongoing analysis of both the students' reasoning and the learning environment. The size of the research team and the expertise of the members." After this workshop was completed, I spent two weeks implementing and evaluating a PBL lesson in the classroom and reflecting with teachers, students and the foundation staff. I explain the implementation phase in chapter 7.

Figure 54. Teachers working with ZTF staff

Objective	Driving question	Activities	Tools to integrate PBL and ICT	Start date	Final date
To improve students' writing and reading skills by putting into practice classroom moral values	How can the moral values of fourth graders be strengthened while taking into consideration 21st-century skills?	The teacher organized the students into working teams	Teacher write the names on the students on whiteboard	May 18, 2016	May 18, 2016
		The children brainstormed about moral values and formulated questions.	Google search on XO computers	May 18, 2016	May 19, 2016
		They created a conceptual map about the types of moral values using XO computers and mental maps activity to make different map schemes.	XO computers	May 18, 2016	May 19, 2016
		They searched for images on Google and then drew them in their notebooks.	XO computers and notebook	May 18, 2016	May 20, 2016
		Students made a presentation to the class.	XO computers and cardboard	May 21, 2016	May 21, 2016

Table 25. Sample of a direct prototype lesson to integrate problem/project-based learning and XO computers to be tested and refined in the classroom

This prototype was co-designed with the fifth grader teacher to be implemented in the fifth-grade Spanish class. The objective was to improve the students' writing and reading skills while they learned about moral values.

Objective	Driving question	Activities	Tools to integrate PBL and ICT	Start date	Final date
To improve students' writing and	How can third graders' writing and reading skills	The teacher organized the students into working teams.	Teacher write the names on the	May 18,-2016	May 18,-2016

reading skills in Spanish class	be improved by creating a story, taking into consideration 21st-century skills?		students on whiteboard		
		Each team of students created a story.	Use XO computer applications Google search Cardboard	May 18,-2016	May 18,-2016
		The children searched the stories bank (banco de cuentos).	Writing inspiring stories	May 18,-2016	May 19,-2016
		Children draw	Using the TUX paint application on XO computers Cardboard Notebook	May 19,-2016	May 20,-2016
		Students record interviews with other students.	XO computers	May 19,-2016	May 20,-2016
		Each group presented their story to the rest of the class.	Cardboard Drawings	May 21,-2016	May 21,-2016

Table 26. Sample of a direct prototype lesson to integrate problem/project-based learning and XO computers to be tested and refined in the classroom

This prototype was co-designed with the third graders teacher to be implemented in the third-grade Spanish class. The objective was to improve the children's writing and reading skills by writing and reading their own stories.

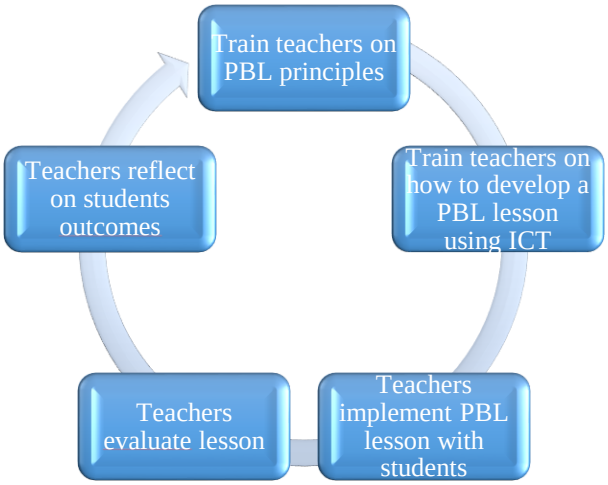

Figure 55. Indirect prototype process to design and implement the intervention

Figure 55, shows the process to design and implement the intervention, first of all, it is highly relevant to train teachers on PBL principles (Table 24). Teachers should develop new pedagogical and technological skills to develop a PBL lesson using ICT. Teachers should be able to implement and evaluate the lesson in the classroom and reflect along with students the outcomes.

6.6 CONCLUSIONS

The prototypes I co-designed with the practitioners meet two goals: to train the teachers and to be used in the classroom. Such prototypes can help improve the conditions caused by the constraints in the classroom context. Designing in this particular context goes beyond adapting a pedagogical model and incorporating technology. It means working in spite of the constraints and focusing on the opportunities, understanding that having a real impact transforming students' mindsets requires more effort from teachers, school administrators, and non-governmental organizations to compensate for the lack of support from the government and relatives directly responsible for the children's well-being.

The socio-economic context should not be a limitation to incorporating an educational model such as PBL. Instead, it should be an incentive to use technology properly, giving students opportunities to become part of the digital age and equipping them with the necessary skills to succeed in the 21st century. In the next chapter, I unfold the two lesson prototypes for third and fifth graders and evaluate and reflect on the results after the last EDR phase.

CHAPTER 7. INTERVENTION PHASE: EVALUATION AND REFLECTION ON INTRODUCING A CLASSROOM LESSON USING PROBLEM/PROJECT-BASED LEARNING PRINCIPLES AND XO COMPUTERS

This chapter was partially published as part of a conference paper (Rivera. M. 2018, pp. 10725-10734).

It describes the third phase of EDR. According to McKenney and Reeves (2012, p. 133), "the term 'evaluation', is used in a broad sense to refer to any kind of empirical testing of intervention that have been mapped out (design) or constructed (prototypes)." Evaluation involves empirical testing, and reflection involves both active and thoughtful consideration of the empirical and theoretical understanding gained.

During this phase, I will describe the pedagogical design constructed in Chapter 6 and I will test and analyze it, using AT to identify the main contradictions and tensions that occurred during the intervention in two primary classroom sessions. Spanish classes for third and fifth graders were chosen to help the students improve their reading and writing skills, one of the main weaknesses in the Honduran educational system, according to the report Progreso Educativo Honduras (2017). I reflect on the results relevant to one research question that contribute filling the gap found in the literature review: What are the main contradictions inherent in shifting from a traditional (teacher-oriented) pedagogy to active (student-oriented) learning using this model constructed in a participatory manner with the practitioners?

7.1 A PEDAGOGICAL DESIGN BASED ON PBL PRINCIPLES

According to Jalkanen and Taalas (2013, p. 76), "Pedagogical design refers to the act of structuring and analyzing the teaching practices and their outcomes in a given teaching setting." Through this study, I have examined teaching practices, conducting EDR as methodology and applying different methods. I presented (Please see Tables 23 and 24, Chapter 6) how teachers were trained on active learning (Prince, 2004), and afterward how they contributed in developing a pedagogical design with a problem-project based learning approach (please see Tables 25 and 26), placing students at the center of the learning process, focusing on developing self-drive learning skills among the students (Lamer et al., 2015).

Jalkanen and Taalas (2013, p. 82) believe that any design needs to be refined, because otherwise the result can be "superficial," and they cite Engestrom (2007), who claims that "no model is ever finished or ready, but in a constant state of change." In this research, shaping a pedagogical model design is a process that involves gathering empirical data, identifying active learning theories, and understanding the appropriate use of XO computers in the pedagogical design.

	Description of the prototypes	PBL Principles (Kolmos, De Graaff, Du, 2009, p. 11)	Learning Theories	Empirical data
Objectives	Objectives are formulated by putting students at the center of the learning process.	Cognitive learning: The objective, in both design prototypes, is to address a problem through developing a project.	The prototype design is based on the Problem-Project Based Learning model, as explained in Chapters 2 and 3. The learning theory is inspired by Dewey, 1902 and Lamer et al., 2015.	The data collected show that the role of the student needs to be changed from passive into active learners. The starting point is to formulate the objective prototypes putting students at the center of the learning process. (Please see Chapter 4, Table 17 and Chapter 5, Figure 47).
Driving question	The project starts with an open question to catch students' interest. This driving question is based on a real problem to motivate children to work in teams to find a solution.	Cognitive learning: The problem is formulated through driving questions.	Challenging problems or questions are part of the essential project design elements shown in this study in Chapter 3, Figure 12 (Lamer et al., 2015) and inspired by Freire (1970) who proposed the pedagogy of the question rather than the pedagogy of the response.	Driving questions serve as guidelines for students as they start looking for a solution through developing a project. Teachers were not familiar with this kind of question. In Chapter 6, I used driving questions as a starting point to train teachers on PBL. Teachers used it in the design prototype

				for third and fourth graders. (Please see tables 23, 25, 26).
Activities	The activities are designed by the teacher to stimulate students' engagement and participation. The students are organized to work in small groups. Each group should use the brainstorming technique and create a conceptual map using XO computers. They use other school supplies, such as cardboard and notebooks, to prepare a presentation. Students have a voice and choice during the whole process and the final product is to make a public presentation.	Collaborative learning: Students work in teams and develop each activity by themselves. Cognitive learning: The project is developed by students to gain experience and build knowledge. Content: Students should solve the problem from a theoretical perspective and put it into practice by developing an artifact (drawing, public presentation, writing a story, etc.)	The classroom activities are based on PBL (Buck Institute of Education, 2015). Also, these activities are inspired by Freire`s criticism of banking education. Freire (1970, p. 59); Dewey (1916); Buck Institute for Education. Gold standard project-based learning: Essential project design elements (Lamer et al., 2015, p. 34)	In chapter 4 (Figure 29, Process of a traditional science lesson delivered to third graders and Table 12, Teacher-student contradictions, Freire, 1970), I found that teachers face pedagogical constraints, and therefore that a teacher-oriented approach needs to be shifted to a student-centered approach.
Tools to integrate PBL and ICT	Internet and XO computers are an important part of this design, but also the use of traditional	Collaborative learning: Participants direct their learning process. Students use ICT to self-discover knowledge and teachers become facilitators.	Constructionism embraces that computers are means in the learning process and children use them as tools to achieve their learning goals and	Empirical data collected during the analysis and exploration show that teachers lack training in the proper use of

	tools (whiteboards, cardboards, and notebooks) plays an important role in developing the activities.		construct knowledge by themselves (Papert, 1982; Lamer et al., 2015).	XO computers and pedagogy (Please see Chapter 4, Tables 19 and 20; Figures 26 and 42).

Table 27. Presents the principles and theories behind the pedagogical design

Table 27 describes the common PBL principles behind these pedagogical designs: cognitive learning, and collaborative learning and content (Kolmos, de Graff, & Du, 2009, p.11). The learning theories are based on a PBL approach as the core pedagogical model and XO computers (ICT) are integrated as tools to boost self-driven learning on students' mindset. These designs respond to the needs identified during the empirical data collection while conducting the different phases of EDR. The design prototypes conceived using EDR methodology are not final and need to be tested and improved in a natural classroom setting.

In the next section, I will describe the process of introducing a prototype lesson in the classroom and I will analyze the contradictions of introducing a student-centered approach based on PBL principles using XO computers as mediators. Also, I will propose a pedagogical design model result from the prototype implementation.

7.2 USING THE ACTIVITY THEORY LENS TO EVALUATE A PROTOTYPE LESSON

In this section, I use AT to identify the main contradictions and tensions that occurred while implementing prototype lessons for third graders and fifth graders at the school studied, Padre Claret. These two groups of students enabled empirical testing of the lessons implemented by the teachers who attended the earlier workshop on PBL principles. This research explored the contradictions among subject–tools–object, subject–object–rules–division of labor, and community–tool–object. (Engeström, 1987)

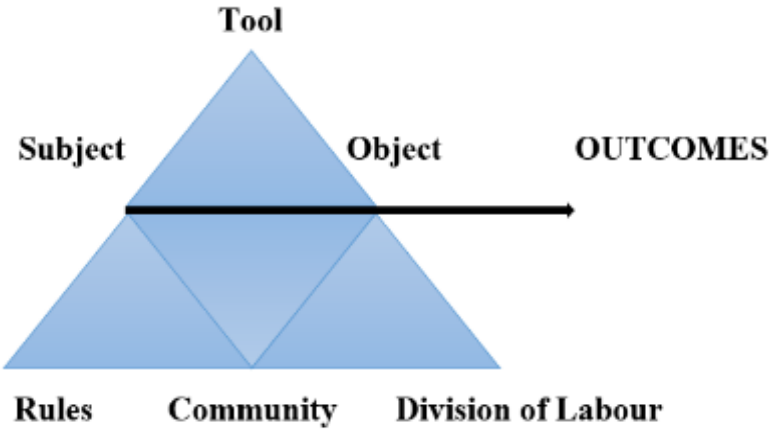

Figure 56.Engeström's (1987) representation of a collective activity system

The present study used AT to identify the main contradictions inherent in shifting from a traditional (teacher-oriented) pedagogy to active (student-oriented) learning. The subject school faced a complex external context with high levels of crime and poverty. The school's internal context was also complicated, characterized by large class sizes, teacher-oriented pedagogy, high dropout rates, literacy problems, and a lack of adequate infrastructure and control over computer activities. To identify the main contradictions when introducing PBL principles and XO laptops into these contexts, the researcher used AT to analyze one activity system: students learning with the active pedagogy of PBL using XO laptops to develop 21st-century skills.

7.3 CONTRADICTIONS

Engeström (1987) identified four types of contradictions: primary, secondary, tertiary, and quaternary. The first two occur within each constituent element of the central activity system, and the last two between two or more different activity systems. According to Nardi (1996), contradictions manifest as problems, ruptures, breakdowns, and clashes. AT sees contradictions as sources of development; activities are virtually always in the process of working through contradictions.

The present study analyzed primary and secondary contradictions related to the central activity and occurring within each of its elements (Ekundayo, Wang, & Andrade, 2012). The unit of investigation was the students in the classroom setting, and the investigation was conducted at the micro level, searching for the main contradictions inherent in using XO computers as a tool to mediate the introduction of PBL, a pedagogical model opposed to the traditional model in which teachers rule the classroom. In contrast, in the approach used in the study, teachers acted as facilitators.

7.4 UNFOLDING THE INTERVENTION

This section presents two cases, one with third graders and one other with fifth graders. The study participants were teachers who received five days of training in PBL principles and XO computers during an earlier phase of the research. During this training, the teachers designed a prototype lesson to be tested. The classroom implementation of the prototype lesson took five days. It was originally planned for three days, but the lesson plan took more time than expected, so the implementation was adjusted accordingly.

7.4.1 CASE 1—THIRD GRADERS

Ms. Dania Lainez was the morning-session teacher for third graders, who worked 7 a.m. through noon, Monday through Friday. She served a large class of 48 students and taught all subjects. She chose to participate in the present study using her Spanish class, with the goal of improving the students' reading skills. Lainez volunteered to implement a lesson design integrating PBL principles and XO laptops, as illustrated in the activity system presented in Figure 57.

7.4.1.1 SUBJECT–TOOLS–OBJECT

Lainez asked the students to take the computers out the lockers, where they were stored. The students could not take the computers home because the school was in a dangerous area, and the students might be robbed of their computers if they took them from the school. Lainez waited until all students had their computers ready to work, which took about 20 minutes, because some students needed to charge their computers' batteries, and there were not enough electrical outlets were available (Figure 58). The teacher organized the students into groups of six to nine, wrote the names of those in each group on the whiteboard, and asked the student groups to arrange their desks in a circle.

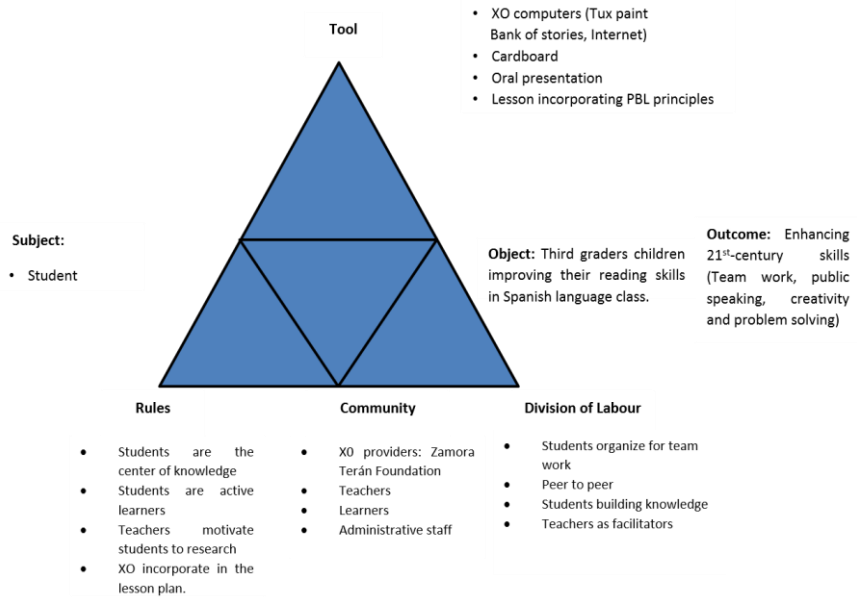

Figure 57. Activity system of student-centered learning for third graders

Figure 58. Students charging XO laptops

Lainez then asked her students to create a story, using the XO laptops to search for images and information, read information, and write their stories. To draw, the students used Tux Paint, and to record interviews, they used the XO cameras (Figure 59). Each group's final product was a story they read aloud in front of the class (Figure 60).

Figure 59. Students using the XO interview app

Figure 60. Group oral presentation

The students' interactions while using the XO laptops as mediators to improve their reading skills were tense because some students needed to charge their batteries before they could begin the activity. The Internet connection was slow and sometimes interrupted, making it difficult to research using the XO laptops. However, the XO laptops had the advantage of being able to work offline because they were designed for use in low-income countries, were durable, and worked under poor conditions. The laptops included 64 educational applications, all open-source, user-friendly software, and had the same specifications as standard computers. One Laptop Per Child Organization (2018) emphasizes in its website that "software tools for exploring and expressing, rather than instruction."

During this activity, the teachers' role was as a mediator, and it was not easy for her to keep the attention of the large group of children. They were not focused on the instructions she gave them but were distracted, played, and talked. Ms. Laínez helped some students turn on their computers while trying to capture the attention of the entire

group. After giving instructions, she went around to each group to be sure they understood the assignment.

7.4.1.2 SUBJECT–OBJECT–RULES–DIVISION OF LABOR

In this activity system, the teacher worked as a facilitator, and the students became the center of learning. This was a new role for students, who were used to playing passive roles. The computers were used as an extra layer in addition to the task rather than integrated into the lesson. The students developed skills, including communication, collaboration, and teamwork. The division of labor was aligned to the rules but was new, and students had to get used to this new style of learning.

The division of labor was changed, with XO computers and the teachers acting as mediators as the children discovered and researched. The teacher facilitated the processes, but the children built their own knowledge. The students talked more about how to solve the problem, leading to natural, peer-to-peer interactions. However, the researcher observed that the third graders required more teacher intervention to answer questions, clarify doubts, and settle disagreements as they learned to work in teams. In an interview, Laínez noted that she had to help the children make group decisions and that "all children wanted to present during the oral presentation and wanted their own drawings to be chosen, and they argued with each other and could not agree, so I had to resolve these situations by choosing what to do" (Figure 61).

Figure 61. Teacher facilitating a class

7.4.1.3 COMMUNITY–TOOL–OBJECT

ZTF was a nonprofit organization providing XO computers to schools in socially deprived areas. Each child and teacher in the school received a computer as part of this program aimed at improving the quality of education. The participating teachers were also trained in the use of XO computers and their 64 applications and, moreover,

in student-centered pedagogical skills. In addition, the administrative staff was trained to support this activity. A contradiction that may occur in the educational community was paying more attention to technology itself rather than to the investment of resources to ensure that teachers had sufficient pedagogical skills to strengthen students' active learning and acquisition of 21st-century skills.

7.4.2 CASE 2—FIFTH GRADERS

The next implementation experience was with fifth graders, whose teacher, Gloria Hernandez, taught all subjects to 40 children in the morning session, Monday through Friday. Hernandez volunteered to participate in the implementation after taking the introductory PBL workshop during an earlier research phase. She chose to develop a Spanish-class lesson using PBL principles and to integrate XO computers as a tool to mediate the process of learning through researching and working collaboratively in teams. This activity system is presented in Figure 62.

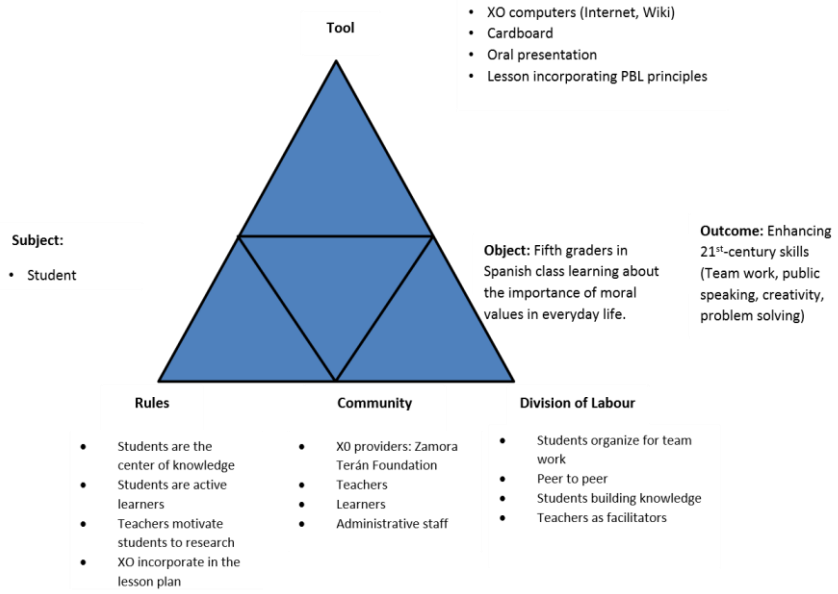

Figure 62. Activity system of student-centered learning for fifth graders

7.4.2.1 SUBJECT–TOOLS–OBJECT

Hernández wrote on the whiteboard all the ethical values children needed to know and defined the research question to be investigated: how to strengthen ethical values in human beings. To mediate the research, the students used the XO laptops and no other digital tools, including the whiteboard, cardboard, class lesson, or the teacher. The researcher interviewed some students, including Luna, who explained what they did step-by-step: "We searched the Internet for the meaning of values. We used one of the

XO applications to write, edit, and save text. The thing that I liked the most was searching the Internet with my teammates."

Figure 63. Students giving an oral presentation

A major outcome of this activity was that each group used cardboard and the whiteboard to prepare an oral presentation on its research findings. Each group named one student to present on its behalf (Figure 63).

During these activities, tensions between students and access to technology occurred due to the slow Internet connections and insufficient school supplies, such as cardboard and glue, to create the presentations. More material supply had to be bought, and it was difficult for members of one group to contribute to this; only 3 of the 7 members could afford to contribute.

7.4.2.2 SUBJECT–OBJECT–RULES–DIVISION OF LABOR

In this activity, the rules and division of labor-motivated students were tapped by using an active learning style, and children were more participatory and very focused on searching for answers by themselves. The teacher was a facilitator, the students built knowledge, and peer-to-peer support was part of each group's dynamics. The children discovered a new application, mental mapping, and learned how to elaborate mental maps by themselves (Figure 64).

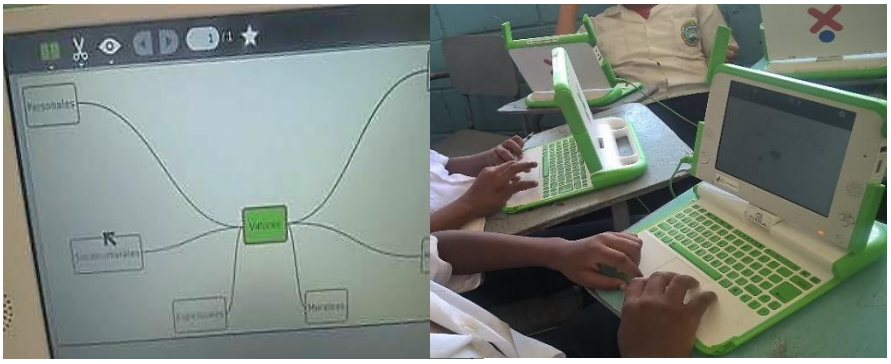

Figure 64. Students working on mental maps and exploring the application by themselves

During an interview, Hernandez, who had observed each group while it worked, noted that her students were very focused and talked only about the assignment. She added, "When one student tried to talk about a different topic, the students shut him up."

One student interviewed, Donald, was excited to work with his amigos and happy to be the leader of his group. He said, "I enjoyed giving the instructions, and they did what I asked them to do, but they all gave their own opinions, and we tried to agree without fighting. We used the mental map application and researched values, including friendship, peace, honesty, and loyalty. We had done a similar project with the teachers before, but it was about drawing a teddy bear together."

Another student interviewed, Juan, pointed out that his group had some problems agreeing and had divided opinions on whom to choose to write on the cardboard. "We chose Luna, but other kids were fighting to choose someone else." Again, the main contradictions identified were the limited school supplies. Otherwise, the team members worked together during this process despite their disagreements. They learned teamwork and new lesson content at the same time (Figure 65).

Figure 65. Students preparing for an oral presentation

7.4.2.3 COMMUNITY–TOOL–OBJECT

As in case 1, the teachers, administrators, and ZTF staff were key to this process. A main contradictions identified was that educators and ZTF need to work on a pedagogical model extending beyond providing access to technology to include enabling students to "learn to learn" and to develop 21st-century skills.

7.5 IDENTIFIED NEEDS

The elementary school involved in the study lacked adequate infrastructure, it applied a teacher-oriented pedagogy, and its teachers had to teach large classes of up to 40

students. In addition, the potential of XO computers to mediate the learning process was undermined by a lack of training to enable the teachers to integrate into technology, student-centered pedagogy, and 21st-century skills into their classrooms.

7.6 TOWARDS A PEDAGOGICAL DESIGN MODEL

I followed different steps toward this first attempt to design a pedagogical design model. As represented in Figure 66 I followed four steps: First, I identified the internal and external constraints (Chapter 4, Table 21). Second, I constructed and implemented the prototype lessons in the classroom (Chapter 6, Tables 25 and 26), in collaboration with the teachers and the researcher. Third, I tested the prototype lessons in the classroom (previously discussed in this chapter) and fourth I start shaping the pedagogical design.

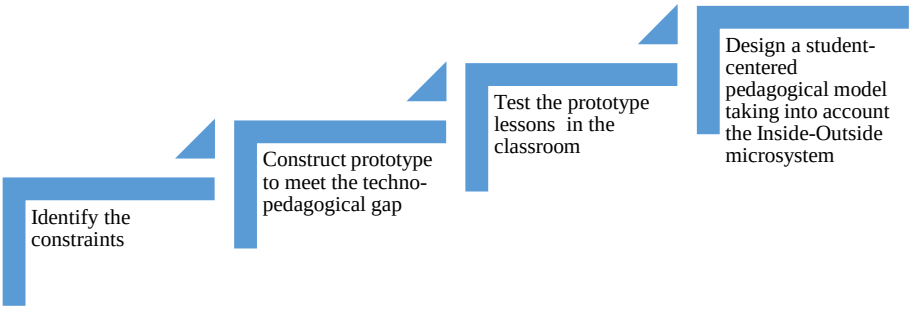

Figure 66. Steps toward design a pedagogical model to use in deprived areas

The pedagogical design model represented in Figure 67 resulted from the empirical testing of the prototypes in the classroom; this design was shaped by the students, teachers, and researcher. The pedagogical goal of this design aims to develop 21st-century skills through a student-centered learning to empower children living in impoverished areas to break the generational cycle of ignorance by gaining the required soft-skills to navigate and succeed in the digital society.

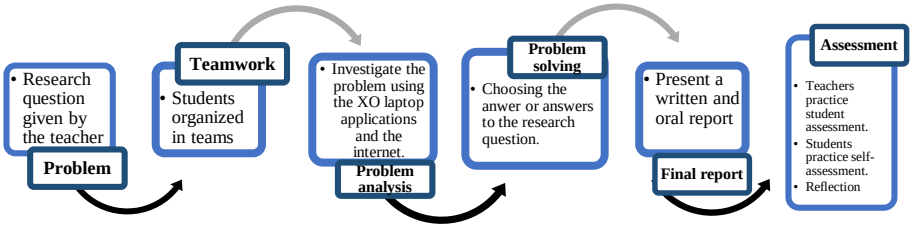

Figure 67. Pedagogical design model resulting from the empirical testing in the classroom

In this pedagogical design, the teacher-student relationship is horizontal, they implement scaffolding strategies to support learners in the process. Teachers respect the individual way of learning and act as a facilitator in the classroom giving coaching and feedback. Children become part of a learning community integrated by teachers and their classmates, as they engage in an active and collaborative relationship of mutual support and respect, practicing assertive communication.

The methodology of this pedagogical design promotes that children learn by doing, solving real problems aligned with the demands of their underprivileged context. From an early stage, children can develop their projects using the scientific method involving the appropriate use of ICT for self-learning and developing 21st-century skills to strength the Inside–Outside microsystem in which they study and live in.

The assessment process is formative, teachers and peers provide feedback, the learner also practices self-assessment, reflecting on their own learning achievements and struggles.

This pedagogical design represented in Figure 67 puts students in the center of learning, as most generic PBL models do, but what distinguishes this from other models is that need to be aligned to the microsystem Inside-outside, as represented in Figure 68, taking into consideration the children`s underprivileged context at the moment of designing and implementing the lesson in the classroom, keeping in mind how to contribute to break the circle of ignorance that is passed on from one generation to the next.

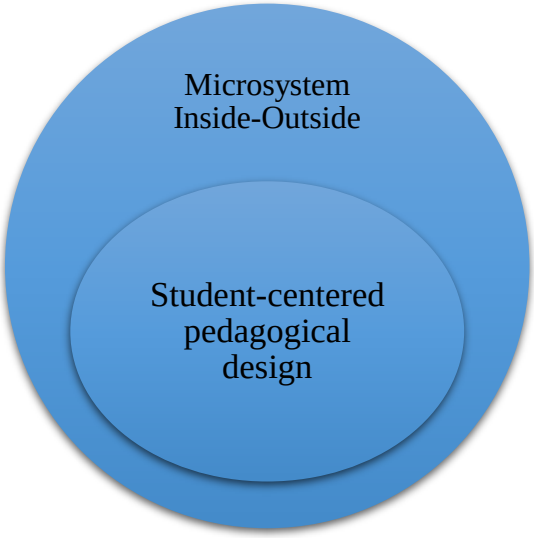

Figure 68. Pedagogical design aligned to the microsystem inside-outside

Figure 68 represents how the pedagogical design and the microsystem Inside-Outside are aligned and work in an interdependent way. Inside the classroom students develop a strong sense of belonging, the students work in teams in a peer to peer supportive interaction, they try to solve real-life problems affecting their context, with the guide of their teachers acting as facilitators, students develop problem-solving skills. They can use XO computers provided by NGOs (due to the absence of government support) use the Internet and other educational software offline and additionally they use traditional school supplies (e.g. notebooks, cardboard, etc.) for self-learning and discovering with their peers.

On the other hand, the pedagogical model also impacts outside the school, students develop real projects that are related to issues affecting their context and they bring home new knowledge and experience to share with their family and community. In most cases it is unrealistic to expect that children will receive academic support at home by their illiterate relatives, in this particular setting, most children are not able to complete their homework by their own if they do not understand the assignment and there is no one at home to help them with homework (Chapter 4). One way to narrow this gap is allowing children to take the computers home and use them as a pedagogical resource, but currently it is not possible to do so, because their neighborhoods are considered dangerous and they can put their lives in danger in case someone wants to steal their computers (Chapter 4 and 5 describe the context).

Elements	Focus questions	Microsystem Inside-Outside
Problem	What do the children investigate?	A real problem related to student context (e.g. school, family, and community)
Teamwork	What kind of soft-skills do children need to develop?	Children develop 21st-century skills such as teamwork, problem-solving, writing, and public speaking, they put into practice new skills, inside and outside the classroom.
Problem analysis	How do children use ICT to investigate the problem?	XO computers are used in the classroom to research the problem. Students self-learn and engage in collaborative learning with their peers.

Problem solving	How do children reach the solution or solutions?	Students learn to learn using ICT, working with their teams and receiving teachers` support. They follow scientific method principles: Observing; formulating research questions and hypothesis (when appropriate); making an experiment (when appropriate) collecting and analyzing the data; presenting the results and inviting others to use it.
Final Report	How do children convey the results?	Students hand in a written report and give an oral presentation to the audience composed of teachers and peers (inside microsystem) and extending the invitation to external stakeholders such as community leaders, relatives, non-profit organizations, universities, private sector and so on (outside microsystem).
Assessment	What kind of feedback do children receive?	Students self-assess, reflect on what they have learned and receive feedback from teachers and peers.

Table 28. Aspects to consider when designing a PBL lesson in an underprivileged school

Table 28 presents the elements of the pedagogical design proposed in Figure 67 and pose questions to guide teachers to design a PBL lesson taking into account the microsystem Inside-Outside previously represented in Figures 49 and 68.

Teaching and learning in an underprivileged school demands a major effort from learners and teachers, for this reason, is so important to consider the deprived context in which the school operates.

7.7 REFLECTIONS AND CONCLUSIONS

The use of technology in the classroom is not new. In the past century, television and radio were introduced to replace the blackboard and chalk, and in some cases,

technology replaced teachers (Cuban, 1986). The present study investigated using technology in the classroom and training teachers to shift from a traditional pedagogy model to a new, more collaborative approach focused on student-centered learning. As Ryberg (2013) stated, technology enhances learning and provides a vehicle for reshaping pedagogies into more active, student-centered, dialogical, collaborative, and knowledge-creating modes of learning.

The learning theory of constructionism holds that children must learn to communicate with computers, and in this process, learning goals are set in a different way (Papert, 1980). Technology is a medium that accommodates individual learners' pace of learning while enabling them to create new things, build knowledge, and "learn to learn."

In the context of poverty, the role of schools should go beyond the transfer of knowledge to training students in using ICT and equipping them with 21st-century skills. These research results show that technology is always changing and providing new devices that can be incorporated. Digital devices have strong effects on how students communicate and how teachers adopt a student-centered pedagogy to teach children to handle technology resources. ICT accommodates a wider range of learning styles and can be used to equip students with 21st-century skills by providing them with opportunities to express themselves in different ways, including through writing and public speaking, and to practice creativity, critical thinking, self-discovery, and peer education.

Building a pedagogical design model (Chapter 7; Figures 67 and 68 and Table 28) to implement in the classroom presents techno-pedagogical and social challenges. However, some of these limitations can be overcome by systematically training teachers in PBL and other active learning styles, strengthening teachers' pedagogical skills to integrate technology, and using traditional resources, including whiteboards and school materials with a learner-centered approach. Including the development of the 21st-century skills in lessons planning is essential to change traditional educational paradigms. Also, the Inside-Outside microsystem (Figure 68) has to be considered as a key cross-cutting issue at the moment to design. Moreover, when implementing a new design, it is important to consider the age of the students because the researcher noted during this study that the third graders needed much more teacher involvement than the fifth graders.

In the impoverished social context in which the school studied operated, the environment posed threats to teachers and students because crime, gangs, extreme poverty, and overcrowding were part of their daily reality. The school cannot solve this situation on its own, but it could influence what and how its students learn in the classroom, provide them with opportunities to "learn to learn," and strengthen their mindsets to succeed in a complex environment.

CHAPTER 8. CONCLUSIONS

In this study, I have pursued two goals: one, to examine the constraints from a theoretical perspective and, second, to propose a pedagogical design using XO computers to introduce PBL. I have answered the four research questions guiding this study. In this part, I present the findings from the results of the implementation of the three phases of EDR methodology.

8.1 DISCUSSION OF THE FINDINGS

RQ1. What are the main constraints to overcome in order to introduce PBL using ICT in public schools operating in impoverished areas?

This first question is aimed at identifying the main limitations faced by the practitioners when teaching the classroom. After unfolding the analysis and exploration phase (Chapter 4), I found that examining the external and internal contexts was key to later designing lesson prototypes using XO computers as a mean to introduce PBL in an underprivileged context.

Regarding physical and nonphysical constraints, the findings conclude that technological constraints are not the only limitations; it is necessary to also address the constraints of pedagogy and children's well-being. Teachers working in deprived areas face many challenges, including risks to their own security risk and that of students. Parents in low-income families often lack economic and educational resources to help their own children. Schools play an important role giving students possibilities to learn to improve their situation and succeed in the hostile environment.

As mentioned in Chapter 4, teachers' main challenge is to incorporate XO computers and student-center pedagogy approach in the classroom to equip students with 21st-century skills. The literature reviews reveal that one of the main constraints to applying PBL is teachers' lack of training in this pedagogical approach, as well as limited access to technology and appropriate infrastructure (Chapter 2).

The findings suggest that external constraints outside the classroom, such as dangerous neighborhoods and low-income families, cannot be addressed only by the school but must also be handled by external stakeholders, such as the public sector. This research is limited to unfolding a worst case. The effects of the external environment on children need to be addressed through the Inside–Outside microsystem to support children's education in the classroom (Chapter 6; Figure 48). The pedagogical design boosts a student-centered approach to strengthen the microsystem (Chapter 7; Figure 67 and 68; Table 28)

RQ2. What kind of design can contribute to implementing PBL using ICT to enhance 21st-century skills?

This research question is intended to help understand the similarities and difference between problem-BL and project-BL and to study the use of ICT, in this case, the application of using XO computers and the Internet to develop 21st-century skills of critical thinking, problem solving, communication, and collaboration. The findings show that there are different PBL models, which cannot be copied exactly across the varying cultures of educational institutions. Their core learning principles, though, can be adopted: collaborative learning, cognitive learning, and content (De Graff & Kolmos, 2003, 2007). It is possible to design a model to implement it in the school regardless of the context. These research findings suggest that implementing PBL in areas with high poverty levels can improve the learning process. The findings show that changing teachers' mindset toward how they teach children from deprived, low-income backgrounds can boost children's potential and success in school (Chapter 2; Jensen, 2009). The research findings support a model based on Dewey's principles of child-centered teaching connecting multiple subjects, on the teacher's role as a facilitator; and the framework of the BIE's (2015) gold standard PBL based on Dewey (1916) it was explained in Chapter 3.

The findings from the second phase of EDR (design and construction) show that practitioners can contribute to designing lesson prototypes. However, they first need to be trained in PBL principles so that with the research, they can design a prototype to shift from a teacher-oriented approach to PBL and later test that prototype in the classroom. The findings stress the importance of putting children at the center of learning, but it is also necessary to train teachers in PBLs, and they need to be eager to use technology in designing lessons including key 21st-century skills (Chapter 6). Furthermore, implementing the lesson design prototypes in the classroom resulted in a final model tested by the teachers with their students. This finding provides new insight for me as a researcher and for the teachers as co-designers into how elementary school children can help shape design. This finding can inspire educators in other impoverished areas of the world to design their own lessons to integrate PBL, 21st-century skills, and XO computers or other devices into classroom design (Chapter 7).

RQ3. What are the main contradictions inherent in shifting from traditional (teacher-centered) pedagogy to active learning (student-oriented) using a model constructed in a participatory manner with the practitioners?

This question is intended to determine the tensions or contradictions resulting from introducing a student-centered learning process by implementing a lesson developed with the teachers participating in this research. The findings suggest that when shifting from a top-down teaching style to a new approach making students the center of learning, the participants confronted technical difficulties in using technology. Hence, the findings show that as the students used XO computers as mediators to improve

their reading skills, the tension between the subject and the tool (the students and XO computers) had to be overcome before the lesson started. Otherwise, it could become a contradiction, undermining the lesson implementation in the classroom.

As teachers assume a new role as mediators, they in practice produce some tension, particularly because they need to implement the lesson while playing a new role. The findings show that teachers need to learn to interact with large groups of students while shifting from the traditional role as the center of the knowledge to become facilitators, enabling children to engage in an active model of learning. In this study, the fifth-grade teachers easily adopted this new role as their students worked by themselves. However, tension between from the third-grader teacher and students was evident. Sometimes, the teacher had to assume her old role, and the class become more teacher oriented, despite the contradiction this raised as the children assumed they could a student-center role.

These findings suggest that students' age affects the participants' interaction. I conclude that the implementation of this model design presents technological and pedagogical challenges, and at the moment of design, it is important to consider the students' age to create appropriate design lesson. I find that introducing PBL supported by XO computers can be replicated in all grades at this elementary school and can be implemented in other schools with similar internal and external contexts (Chapter 7).

RQ4. How can a new model design in the classroom contribute to enhancing the 21st-century skills of children attending schools operating in impoverished settings?

This research question concerns the importance of equipping children with 21st-century skills (soft skills) so they can transform their own reality. This research considers introducing skills to be relevant to students' mindset (Scott, 2015), and the literature review shows that active learning more effectively involves students in the learning process, even in deprived areas (Prince, 2004, p. 224; Savin-Baden and Howell Major's, 2004, p. 7; McKenney & Brand-Gruwell, 2015), in Chapter 2 is discussed. While testing the lesson prototype in the classroom, the teacher acted more as a facilitator, especially with fifth graders. The third graders needed more support and direction from the teacher. In both cases observed, though, students put into practice the following 21st-century skills: teamwork, problem solving, writing, and public speaking (Chapter 7). Students became the center of knowledge and learned a new way of interacting in which they have voice and choice (Lamer, 2015).

Another finding shows that children learn to use more XO applications by themselves and are eager to share the new applications with their peers and teachers. All the participants were open to learning and participating to solve the problems and develop the projects. It is relevant to highlight that the students used computers and other school supplies, such as pencils, notebooks, cardboard, and markers, to prepare their

public presentation. This finding shows that the 21st century goes beyond technology and humanizes interactions, focusing on children's need to improve their skills become priorities.

During the implementation, learning by doing and learning to learn were observed, and the teachers were able to practice student assessment, while student assessed their own participation and reflected on the results. An important aspect to highlight is that despite the constraints and contradictions identified, it is possible to enhance 21st-century skills with current technology, though it is necessary to improve teachers' pedagogical skills. Children need a more open, friendlier atmosphere to develop their skills, gain self-confidence, and become the center of knowledge.

8.2 REFLECTIONS ON CONTRIBUTIONS

Conducting this study has strengthened my skills as a researcher, facilitator, and designer. Adopting EDR as the methodology proved to be an excellent choice, because it allowed me to contribute from a theoretical perspective and to understand the limitations of introducing PBL, 21st century skills and ICT in underprivileged schools, and to develop practical solutions with the practitioners.

8.2.1 THEORETICAL CONTRIBUTION

I do not pretend to have developed a theory from a single case; however, EDR leads to the development of theories with different purposes—to describe, explain, predict, and prescribe—and at different levels: local theory, middle-range theory, and high-level theory (McKenney & Reeves, 2012, p. 38). The theoretical contribution of this research is descriptive, since it "describe[s] a real-world phenomenon," explanatory, "derived from empirical observation," and "provides reasons for why learning does or does not occur" (McKenney & Reeves, 2012, p. 33). I have partly contributed to filling the literature gap on PBL in elementary schools operating in deprived areas, introduced the use of ICT as a mediator, and highlighted the importance of developing 21st-century skills among students from low-income families (Scott, 2015; Halvorsen et al., 2012; Gorski, 2013; Asan & Haliloglu, 2005).

In this process, I generated a local theory, applicable to a deprived school facing physical and non-physical constraints preventing the teachers from delivering quality education in the classroom (Landau, 2009). As Cobb, Confrey, diSessa, Lehrer and Schauble (2003, p.10) indicate, "Theories developed during the process of experiment are humble not merely in the sense that they are concerned with domain-specific learning processes, but also because they are accountable to the activity of design." I proposed to strengthen the *microsystem* that I call *Inside-Outside* to support children's education in impoverished areas (Chapter 6; Figure 48) and aligned with the pedagogical design (Chapter 7; Figure 68 and Table 28). Inside: schools fill the absence of government action on public education with private support from NGOs;

the lack of family engagement is offset by teachers trained on appropriate pedagogical skills such as PBL and other active learning skills and a peer-to-peer program to stimulate children to learn from each other. Outside: Students become ambassadors to share the new skills and knowledge with their families and their communities. Freire (1970) points out that a non-banking education is necessary to liberate the oppressed, so that they are capable of thinking in new ways to transform their own environment.

My local theory is based on the findings of the analysis and exploration phase. In Chapter 4, I conducted a survey to understand the school context, and I found that all the children come from low-income families, raised by their parents, single mothers, and extended families. Children don't receive family support to complete their school homework, they lack computers, Internet, and any other kind of resources to consult at home (books, newspapers, magazines, etc.). Also, in chapter 5, as part of the second phase (design and construction), I conducted the Socratic method (Wang, 2011; Goldratt, 1990) and I found that teachers are concerned because most parents are illiterate—they could hardly read the invitation letters to attend school meetings. If the parents or guardians cannot read and write, the children cannot receive assistance to finish their homework.

During this dialogue, a teacher proposed to develop a special program to train children as tutors for disadvantaged students and to train students using a PBL approach (Solis, Larmer, & Olabuenaga, 2015). As educators, they understand the external context that children face every day—dangerous neighborhoods, high rates of crime, poverty, and broken families (Bowen & Bowen, 1999) and they suggest that students' opportunity to "learn to learn" is in the classroom, so they could learn to solve real-world problems and transform their own environment (Ronis, 2007). The participants also proposed adopting a peer-to-peer model to overcome the lack of teachers' assistants, especially with large classes (Freire, 1970; Dewey, 2001). Project-BL is an alternative pedagogical method to implement in deprived areas (Gorski, 2013; Giesige, 2017; Jensen, 2009) and strengthening the *Inside-Outside microsystem* can benefit children, making them more likely to succeed in school.

8.2.2 PRACTICAL CONTRIBUTION

"The primary practical contribution of educational design research is the intervention developed to solve a real problem in practice" (McKenny & Reeves, 2012, p. 39). The empirical data collected during the intervention shed light on the importance of constructing pedagogical design integrating XO computers, student-oriented learning and 21st century skills and the underprivileged context (Please see Figures 67 and 68). One important need to solve, according to the data collected through this study, was the lack of training for teachers (Figure 48). To respond to this need, the first prototype that I constructed was a lesson design to train teachers based on gold-standard PBL (Please see Chapter 6, Table 23). I conclude that the pedagogical skills of teachers

must be enhanced through training and they must be our strategic allies in the transformation of the educational model (Ryberg, 2013).

After equipping teachers with new pedagogical skills based on PBL principles, I co-designed, in collaboration with practitioners, two lessons to be used in the classroom (Please see Tables 25 and 26 in Chapter 6). Furthermore, these designs were tested and refined during their implementation in the classrooms (Jalkanen & Taalas, 2013). A model resulted from the intervention with third and fifth graders in collaboration with practitioners (Please see Chapter 7, Figure 67), this refinement pedagogical model (Cobbs et al., 2003) involve the use of 21st century skills: critical thinking, problem-solving, and communication (Scott, 2015; Chapter 7; Table 27), and the integration of ICT and PBL principles (Kolmos, et al., 2009; Lamer et al., 2015; Papert, 1980; Freire, 1970; Dewey, 1963):

1) Problem: A research question is given by the teacher to solve a problem; 2) Teamwork: students are organized in groups to work in a collaborative way; 3) Problem analysis: XO computers and Internet are used as mediators to investigate the problem; 4) Problem solving: students put their analytical skills into practice to answer the research question; 5) Final report: participants present a written report and make a public presentation; 6) Assessment: Teachers practice student assessment and student self-assessment and together teacher and students reflect on the learning outcomes.

I expect that the proposed designs can served as a source of inspiration for researchers and practitioners to replicate or adapt in future design research. However, I hope that these designs are understood from the context in which they were constructed and implemented—in an attempt to improve educational quality in marginalized areas to ensure that students from impoverished neighborhood have opportunities to transform their present and, in the future, are able to access jobs and business opportunities that currently favor only a privileged class. My practical contributions are the result of empirical work with a limited group of students and teachers at the micro level, with the potential to be replicated in areas with similar characteristics to those presented in the research.

8.3 LIMITATIONS AND FUTURE WORK

I consider this investigation to be an exploratory attempt to examine the current constraints practitioners face using a teacher-centered approach and ICT, and the contradictions they encounter in shifting to a student-centered approach in impoverished contexts. In future research, I suggest including all elementary school teachers and ZTF staff members in the implementation, and to encourage some to become research assistants in order to build the capacity to design and implement using a PBL approach in the educators' communities.

The first phase (analysis and exploration) and second phase (design and construction) of this study were conducted with the participation of all teachers in the elementary school. However, the third phase (evaluation and reflection), also considered to be the implementation phase, involved two teachers and students in third and fifth grade. The school principal authorized the time and resources to develop this research.

Future researchers could seek the approval of school administrators to extend the time of the study to investigate the impact of implementing PBL in the classroom and strengthening the microsystem proposed in Chapter 6, the Inside–Outside microsystem, to break the cycle of ignorance. This starts inside the classroom, replacing the absence of the national government with the support of NGOs (e.g., ZTF), and the lack of family support with teachers' and peers' support. Next, it is extended to the outside by students who can use their new knowledge to start making little changes (e.g., eating healthy food, recycling, and applying moral values) to transform themselves, their families, and their communities.

In sum, in this research context the empirical data collected showed that pedagogical problems are not fixed with the introduction of technology, per se. Teachers' practices need to be changed from a teacher-oriented approach, and they need to embrace the use of XO computers or any other technological device accompanied by a student-centered approach such as PBL to motivate children to learn to learn. The use of XO as a pedagogical tool should be standardized and become part of the curriculum, and teachers should play an active part in this process. Technology cannot replace teachers' functions, but their skills and expertise must be scaffolded through systematic training to improve the use of technology in classroom design without losing humanity. This is especially so with students struggling to learn in social risk environments, in which school most likely is the only resource to transform their reality.

I would like to close this study with this final thought:

"Education, therefore, is a process of living and not a preparation for future living." (Dewey & Small, 1897, p. 7)

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APPENDICES

APPENDIX A

Participant observation format

Item	Description
1. Infrastructure	
• Blackboard	
• Computers	
• Internet connection	
• Chairs	
• Desk	
• Ceiling	
• Floor	
• Ventilation	
• Lamps	
• Description	
• Temperature	
• Level of noise	
2. Verbal behaviour and interactions	
• How do teachers interact with students?	
• Who initiate the interaction?	
• Tone of voice	
• Who is interacting?	
• Who is not interacting?	
3. Use of Technologies	
• How do teachers use computers to teach?	
• What other ICT's resources do teachers use to teach?	
4. Pedagogical Model	
• What kind of pedagogical model do teachers in the learning process?	

• How long does it last a class?	
5. Human traffic	
• How often do people enter, leave and spend time at the observation time?	
6. Demography	
• How many boys and girls attend the class?	
• What gender are the teachers?	
• What ethnicity do students belong to?	

APPENDIX B

Teachers interview questions

Research Questions	Interview Questions
1. What are the main constraints to overcome in order to introduce PBL using ICT in public schools operating in impoverished areas?	• What kind of role do you play in the process of learning of your students (teacher-centered or student-centered)? • Do you think that students would be able to accept a student-centered format and embrace a "teacher-independent learning" approach? • Do you think that teachers would be able to accept PBL model? • Is Honduran culture compatible with collaborative learning? • Do you think that is possible to change education paradigm? • How the current school organizational structure may influence PBL implementation?
2. What kind of design can contribute to implementing PBL using ICT to enhance 21st-century skills?	• How do you think that PBL model can contribute to improve students` 21st century skills? • How computer and PBL can work together to engage students in the learning process? • Do children have access to Internet and electronic library to obtain latest information? • Do you think that is possible to use students as tutors to help their peers?

3. What are the main contradictions inherent in shifting from a traditional (teacher-oriented) pedagogy to active (student-oriented) learning using a model constructed in a participatory manner with the practitioners?	• What kinds of barriers do you handle when you are using the XO in the classroom? • How do you think you could overcome those barriers?
4. How can a new model design in the classroom contribute to enhancing the 21st-century skills of children attending schools operating in impoverished settings?	• How do students work better, in groups or individually? • Who is responsible to design the classroom lesson? • In which subjects would you like to implement a PBL approach?

APPENDIX C

Survey

Encuesta para conocer características sociales de los estudiantes y expectativas educativas

Instrucciones: Responda las siguientes preguntas y marque con una X los enunciados que correspondan:

I. Datos generales
Nombre del estudiante:
Grado:
Edad:
Sexo:
Lugar de residencia:

II. Características sociales
Lugar de residencia:
Con quién vives (padres o encargados):
Lugar donde laboran (padres o encargados):
Tipo de trabajo (padres o encargados):
Recibe apoyo económico para venir a la escuela (padres o encargados):
Tipo de transporte que usa para asistir a la escuela:

III. Expectativas educativas de los estudiantes

1. Te gusta trabajar en equipo con tus compañeros:
___Sí (Explique)
___No (Explique)
2. Qué actividades te gusta hacer con las computadoras XO:
___Tareas
___Jugar
___Sumas y restas
___Escribir
___Buscar palabras
___Leer cuentos
___Descubrir nuevas actividades de las XO
___Buscar información sobre comida nutritiva
___Otros

3. Te sientes utilizando las XO en la clase de español
___Entretenido
___Aburrido

4. En que asignaturas utilizan las XO para recibir clases
____Matemáticas

____español
____Ciencias Naturales
____Ciencias Sociales
____Física (deportes)
____Otros

5. Cada cuánto utilizan las XO en el aula de clases
   ____Una vez por semana
   ____Dos veces por semana
   ____Tres veces por semana

6. En que asignatura crees que podrías utilizar las XO
   ____Matemáticas
   ____Español
   ____Ciencias Naturales
   ____Estudios Sociales
   ____Otras (Especifique)

7. Cómo le gustaría que estuviera equipada tu aula de clases
   ____Ventiladores
   ____Aire acondicionado
   ____Mesas tipo escritorio
   ____Data show
   ____Sillas bien pintadas
8. Cuentas con acceso a Internet en el aula para ver videos educativos e investigar tareas
   ____Sí
   ____No

9. Tienes Internet en casa
   ____Sí
   ____No
10. Tienes computadora en casa
    ____Si
    ____No
11. Te ayudan a hacer tus tareas en casa
    ____Siempre
    ____A veces
    ____Nunca

APPENDIX D

Future Workshop Plan

I. Future Workshop

Goal: Exploring the opportunities and constraints to introduce Problem Based Learning (PBL) Pedagogical Model by using computers in schools in order to improve the quality in education in public schools located in marginal areas with high crime rates.

II. Reflective questions

1. What are the constraints that teachers face when using computers in the classrooms?
2. What other problems face when using computers and traditional pedagogy in which the teacher is the center of the knowledge?

III. Duration

- Time schedule
- Introduction- 8:15-8:30 a.m.
- Critique phase- 8:30-9:30 a.m
- Recess-9:30-9:45 a.m
- Fantasy phase-9:45-10:30 a.m.
- Implementation phase-10:30-noon

IV. Participants Profiles

Teacher working with technology in the classroom

Staff from the non-profit organizations (foundation) supporting public schools

V. Resources: The Venue and Accommodation

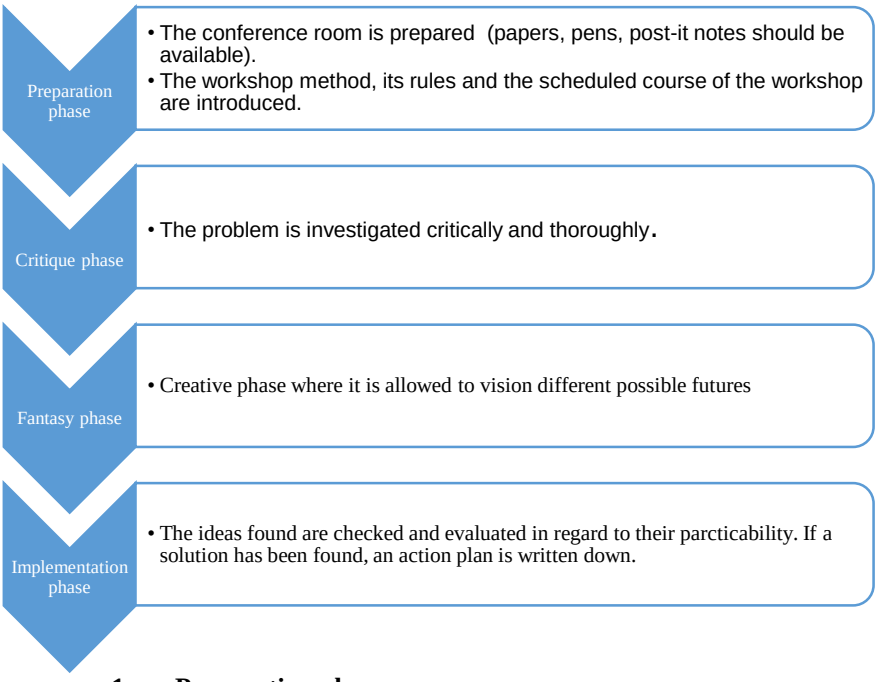
School

Moderator: Mirna Rivera

VI. Materials: Large sheets of paper, sellotape and a variety of coloured felt pens.

Coffee, sodas, water.

VII. Description of Future Workshop phases

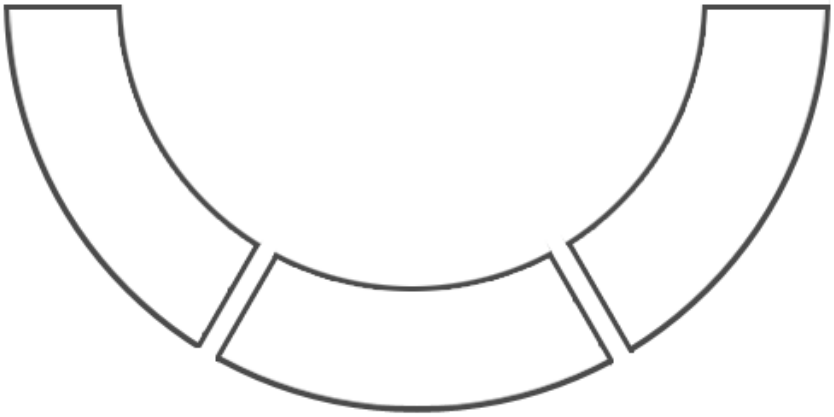


1. Preparation phase

Materials:

- Large sheets of papers and pens
- Post-it note
- Laptop
- Data show
- The facilitator gives an overview on the subject and goals. (15 minutes) Encourage participants to be creative. Participants introduce themselves.
- Start with a game to stimulate creativity among the participants.

The participants will be seated in a semi-circle



Organize groups

After the opening words the facilitator divided in groups of three or four people. These groups are seated in circles. The facilitator role is to encourage groups to critique and fantasied about the questions, keeping in mind the goal.

2. Critique Phase: The problem is investigated critically and thoroughly

Participant will brainstorm with these two questions:

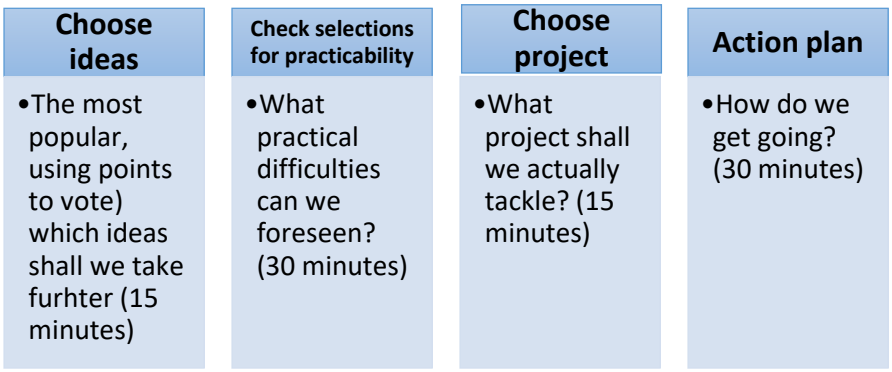
Reflective questions

1. What are the constraints that teachers face when using computers in the classrooms?
2. What other problems face when using computers and traditional pedagogy in which the teacher is the center of the knowledge?

3. Fantasy Phase

The participants will consider the alternatives to the problems identified. They will work in groups. Participants will do graphic representation to present the solution. They will draw a representation. Another alternative would be to write a fictional story

4. Implementation Phase



Selected from the Fantasy Phase, ideas are selected to be implemented. The action plan should respond the questions: what, where, when and how and why.

Fantasy phase	Implementation phase

5. Follow-up Phase

The facilitator will write a final report after the workshop and will share it with the participants.

VIII. References

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